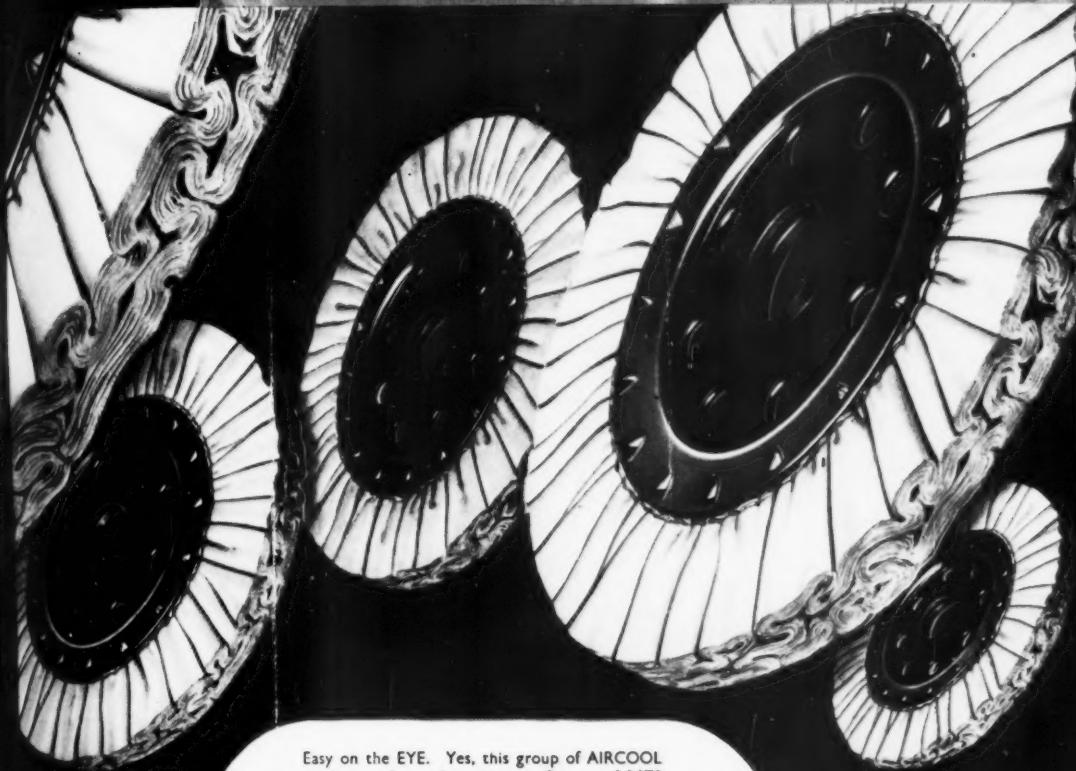


metal finishing

INT. APPLICATION, ELECTRODEPOSITION, VITREOUS ENAMELLING,
EVANZINING, METAL SPRAYING and all METAL FINISHING PROCESSES.

Vol. 2 No. 20 (new series)

AUGUST, 1956



Easy on the EYE. Yes, this group of AIRCOOL sections makes a fine picture. Easy on COSTS as well, for AIRCOOLS save a lot of time and money. The reason — quality is built in to every section and never varies. Easy to change too, they go straight on to your spindles (no loose centres). Made in all diameters and plies from plain and impregnated cloths.

Airc cool Bias Wheels

ARE PREFERRED BY POLISHING SHOPS THE WORLD OVER

JOHN HAWLEY & CO (WALSALL) LTD
GOODALL WORKS BLOXWICH RD WALSALL STAFFS



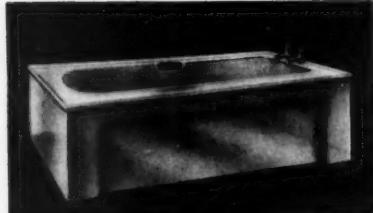
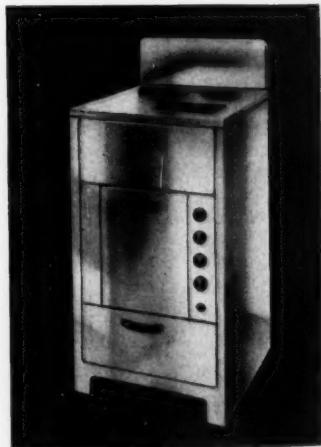
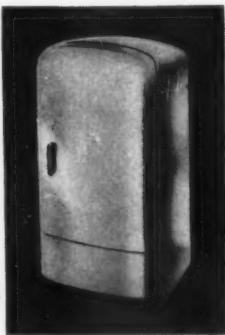
COLOUR - brightens life...

IN the many thousands of new homes now being built, colour in all its applications is used to give visible expression to the present spirit of progress, away from the drab years that have gone before.

Even in places that were once considered pure utility we now find that the old black stove has given place to its clean coloured counterpart, with matching refrigerator and kitchen furniture.

The bathroom has an air of cleanliness and freshness in its pastel shades.

Blythe Colour Works contributes to the sunny scene by supplying enamels, frits and oxides for all purposes and every manufacturing process.



Blythe

COLOUR WORKS LIMITED

CRESSWELL · STOKE-ON-TRENT

THE HOME OF THE WORLD'S BEST COLOURS

metal finishing Journal

August, 1956 Vol. 2, No. 20 (New Series)



Editor: JOHN HOOPER
Southern Area Manager: E. COLLIS
Western Area Manager: E. J. SWEETING
Production Manager: R. J. LOVELL

Managing Editor: ALASTAIR MCLEOD, F.I.M.
Northern Area Manager: G. P. ELLIOTT
Circulation Manager: E. T. GRIFFITHS

Assistant Editor: E. H. LLOYD, A.I.M., A.C.T. (Birm.)
Scottish Area Manager: T. H. SMITH
Eastern Area Manager: ERIC PERRIN
Publisher: H. J. DWYER

Official Organ of the
**INSTITUTE OF
 VITREOUS ENAMELLERS**



President:
SIR GEORGE BRIGGS

Chairman:
W. THOMAS

Secretary:
J. D. GARDOM
 John Gardom & Co., Ripley, Derby
Telephone: Ripley 136

Published on the 15th day of each month by

**INDUSTRIAL
 NEWSPAPERS
 LIMITED**

Chairman and Managing Director:
 Barrington Hooper, C.B.E.
Commercial Director:
 F. Barrington Hooper, B.A.
Director:
 F. R. Lewis
Director and Secretary:
 E. G. Weston

JOHN ADAM HOUSE
17-19 JOHN ADAM STREET
ADELPHI, LONDON, W.C.2

Telephone: TRAfalgar 6171 (P.B.X.)
Telegrams: Zacatecas, Rand, London

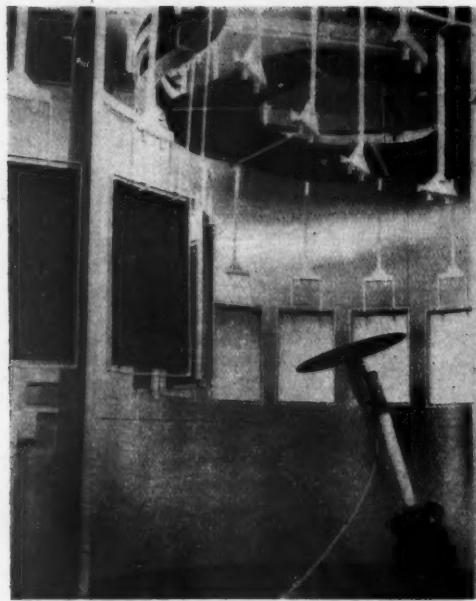
Subscription Terms:
 Home and Overseas 24s. per annum
 prepayable
 Single copies 2s. (2s. 4d. post free)

THIS JOURNAL IS DEVOTED TO THE SCIENCE AND TECHNOLOGY OF PAINT APPLICATION, ELECTRODEPOSITION, VITREOUS ENAMELLING, GALVANIZING, ANODIZING, METAL SPRAYING & ALL METAL FINISHING PROCESSES. THE EDITOR IS PREPARED TO CONSIDER FOR PUBLICATION ANY ARTICLE COMING WITHIN THE PURVIEW OF "METAL FINISHING JOURNAL" AND ALL SUCH ARTICLES ACCEPTED WILL BE PAID FOR AT THE USUAL RATES.

Contents

	PAGE
Ne Plus Ultra	267
Talking Points	268
"Platelayer"	
The Deposition of Nickel by Chemical Reduction	269
<i>A. McL. Aitken, B.Sc., A.F.R.Ae.S.</i>	
Electrostatic Painting—The Ransburg Processes	274
<i>Richard Tilney</i>	
The Belgian Corrosion Research Centre	282
A Comparative Survey of Stoving by Convection and Radiation (cont.)	287
<i>Leo Walter, A.M.I.Mech.E., M.Inst.F.</i>	
Some Notes on the Bi-Polarity of Nickel Heating Coils	295
<i>D. W. Taylor, Grad.I.E.E.</i>	
Finishing Post	297
Personality Spot	298
<i>Sir Ernest Canning</i>	
News Review	301
Plant, Processes and Equipment	303

RANSBURG ELECTROSTATIC PAINTING



In this Photograph panels for Hoover Washing Machines are shown being painted by the Ransburg Electrostatic No. 2 Process at the Merthyr Tydfil Factory of Hoover (Washing Machines) Ltd.

The high quality finish of Hoover Washing Machines is maintained consistently by use of the Ransburg Process with substantial savings in paint usage, labour, and space heating of the paint shops. Our laboratories in London are fully equipped to carry out experimental and demonstration work of all kinds. Our qualified technical staff is always ready to advise and assist in your painting problems.

Henry W Peabody (Industrial) Ltd.

Representatives of the Harper J. Ransburg Company, Indianapolis, U.S.A., for the U.K. and Western Europe.
Manufacturers of Industrial Detergents and Specialised Lubricants.

17, GREAT SUFFOLK STREET, LONDON, S.E.1
WATERLOO 7168

Agents: Paris • Bad Hersfeld • Rotterdam • Brussels • Milan • Zurich
Copenhagen • Oslo • Helsinki • Madrid • Lisbon

A COMPANY OF THE



SALE TILNEY GROUP

ING NE PLUS ULTRA

TH^E bitter frustration of Alexander the Great on finding at a comparatively early age that his military successes had left him with no more worlds to conquer can be appreciated, even though the discovery of sundry new continents later in history proved his discouragement to be premature.

What it really amounted to was that his practice was a long way ahead of his technology. The worlds did in fact exist, but he lacked the fundamental knowledge to be aware of the possibility of their existence and, the technical means of rendering them accessible even if he had suspected their presence.

Even in comparatively recent times it has not been unknown for the view to be expressed that the ultimate had been reached in scientific discovery and industrial progress, and that no further realms of knowledge remained to be penetrated, while in the present enlightened scientific age it would be hard to find anyone prepared to commit himself concerning the direction of the next major scientific or technological advance. On the other hand of course, science and technology seldom advance in major steps, but rather by a series of minor advances on numerous fronts, the sum total of which, over a period of years, can be substantial.

The introduction of chromium plating shortly after the first world war can be considered as one of the major technical advances in metal finishing, whereas the present widespread use of bright-plating nickel solutions, an equally important development, has arisen as a series of evolutionary changes over a number of years.

History also reveals that it not infrequently occurs that a scientific concept or a technological advance arises ahead of the ability of the times to appreciate it or to make effective use of it. Numerous instances can be cited of discoveries whose development has stagnated until they have been virtually rediscovered to meet the needs of a renascent industry.

It is a pastime, which is certainly not without interest, and may well be not without profit, to examine the metal-finishing field in an attempt to classify its techniques under one of these headings already mentioned. An example which springs readily to mind is electrolytic polishing, the original work in connection with which was done over thirty years ago. For long years interest in the process languished, although a crude form of electro-brightening of complicated nickel or silver plated articles by back etching in the nickel or silver strip was not unknown. By slow degrees and by continuous minor contributions to the knowledge of the process it has come to find a limited number of applications, while there are still many who would deny it any real prospects of a major future expansion. But then there were, of course, plenty of people who foresaw no future for that noisy and unreliable, malodorous and costly bundle of mechanism, the horseless carriage, now popularly known as the motor-car.

A much more recent example of the same sort of thing is evidenced by the reception accorded to tin-nickel alloy plate. In our opinion if tin-nickel plating had been made available to the electroplating industry before, or at the same time as nickel-chromium plating, there would be far more tin-nickel plate in evidence today than nickel-chrome, but under present conditions it is not likely to achieve widespread adoption until the present heavy capital investment in chromium-plating equipment has been amortized or rendered obsolescent by increasing use of brightened aluminium.

Coming right up to date we publish in this issue a paper giving details of a process for the deposition of nickel by chemical reduction. It is perhaps appropriate to ask whether this will prove to have been a major technological milestone or a minor advance of interest only in specialized applications.

Talking Points

by "PLATE LAYER"

TOPICAL COMMENT
FROM THE MAIN
LINES AND SIDE
LINES OF METAL
FINISHING

UNCIVIL SERVANTS

RECENTLY, Neville Shute had this to say about civil servants and politicians :—

"... sad experience in aviation before I was forty gave me the conviction that every politician and every civil servant must be regarded as an arrogant fool until he be proved otherwise. When I was a boy early in the century, it was an accepted axiom that a first-class mind with a good classical education could administer any job, merely employing experts for advice on technicalities. My working life showed me how wrong that principle could be, how dangerous it was and how productive of disaster. I think that principle is dying very quickly now, and if by writing my experiences I have stuck another dagger in its back, I think I may have done a worthwhile job".

Probably Mr. Shute is rather sweeping in his generalizations, but can one be as confident as he is as to the future relative status of administrators and technologists? Science masters still hardly ever become heads of important schools, while experts generally are exceedingly rare in the House of Commons, the Cabinet and the highest echelons of the Civil Service.

By the same token Henry Ford once said that when a man became an expert in his organization, he fired him, because experts were on too familiar terms with the impossible. Today the Ford organization has changed all that—but governments have not.

BURMA VICTORY

A LEGAL decision which may have quite far-reaching consequences so far as taxation is concerned, has recently been announced. A British Company disposed of the "know-how" of certain of its processes to Burma for the sum of £100,000 and this was promptly assessed by the Crown as a trading profit for the purpose of income-tax. The Company contended, however, that this was the sale of a capital asset in that it enabled an industry to be set up in Burma, which could then effectively compete with the Company in due course. The Court upheld the appeal and the Income Tax Commissioners lost their case.

As the sale of processes and "know-how" can become an important source of income to this country, it is worthy of note that such a sale can be

made worthwhile in this way; if the revenue has to be added to income in a single year, this type of enterprise becomes singularly unattractive.

PLUS CA CHANGE

WE ARE used to hearing it said that the traffic in Central London now moves more slowly than it did a century ago, but we do consider that on the whole our technical communications are pretty good nowadays.

The wind was therefore taken out of our sails somewhat on hearing some remarks which Dr. Stevenius Nielsen made to the Society of Chemical Industry recently. Speaking of the correspondence between Berzelius and Humphrey Davey, he pointed out that although it took only a few weeks for Berzelius's scientific papers to be published in Sweden a century ago, at least a year elapsed before copies were able to reach Humphrey Davey in London. Today things are only apparently better; papers can arrive in England from anywhere in the world in a matter of days, but such are the delays in publications due to pressure of space in scientific journals that it often takes a year before they get into print. The net result is therefore the same.

ESSAYISTS

ONE often reads that awards by various bodies in essay competitions are not made in particular years, because of a lack of entries of an adequate standard. It is very pleasing therefore to hear that the Corrosion Group of the Society of Chemical Industry, which recently arranged a competition for the best essay on some aspect of the corrosion of metals and its prevention, has had a very different experience.

Fifteen entries were received which were so good that it was difficult to choose the winning essay. In fact the sponsors had to award three prizes instead of one ultimately as a way out of the *impasse*.

It is interesting to note, however, that of the four best entries which dealt with cathodic protection, corrosion in aircraft, inhibitors, and statistical aspects of corrosion research respectively, not one dealt specifically with finishes as corrosion protectives. This is in line with something that has been evident in the industry for years, i.e., the best scientific brains are not being attracted to metal finishing as a career for one reason or another. What are we going to do about it?

The Deposition of

(A paper presented to the Conference on "Modern Processes" organized by the Sheet and Strip Metal Users' Technical Association at the Charing Cross Hotel, London, on April 26 and 27, 1956).

NICKEL by Chemical Reduction

By A. McL. AITKEN, B.Sc., A.F.R.Ae.S.*

THE history of the chemical reduction of nickel is much greater than is generally appreciated. The first published reference is by Wurtz⁽¹⁾ in April, 1844, who reported that a solution of nickel hypophosphite, evaporated at 100°C is partly reduced depositing metallic nickel with the evolution of hydrogen gas. Further work was carried out by P. Breteau⁽²⁾ in 1911 and by F. A. Roux, to whom a U.S. Patent was granted in December, 1916⁽³⁾. Claim 2 of this patent reads as follows:— "The herein described process of producing metallic deposits, which consists in steeping the articles to be treated, until sufficiently metallised in a hot solution of citrate of nickel, an alkaline hypophosphite and ammonia."

However, Roux had not recognized the catalytic nature of the reaction, but in the meantime Bach⁽⁴⁾ in Berlin had studied the "decomposition of water" by hypophosphite in the presence of palladium and had appreciated the latter as a catalyst.

At least four other papers dealing with the reduction of nickel salts in aqueous solution were published during the next 20 years, during which time it was established that metals of the eighth group of the periodic table were the required catalysts for this reaction and that the metallic deposit contained between 3 to 15 per cent. phosphorus.

In 1946, Brenner and Riddell⁽⁵⁾ of the U.S. Bureau of Standards, while studying the effect of depolarizing agents on the electroplating of nickel on to steel, added sodium hypophosphite to their bath solution and measured current efficiencies of more than 100 per cent. The reducing reaction was studied and a laboratory method was developed so that under prescribed conditions nickel could be deposited on to steel or nickel from a hot ammoniacal solution. At this time all the solutions described contained nickel chloride, sodium hypophosphite and ammonium salts. The deposition rate on steel was 0.2 to 0.3 mils[†] per hour. After further investigations Brenner and Riddell⁽⁶⁾ were able to extend their process to include the deposition of nickel from acid solutions and of cobalt from ammoniacal solutions. To this technique they gave the term "electroless plating".

The publication of this work and subsequent granting of a patent⁽⁷⁾ to Brenner and Riddell aroused the interest of industrial concerns, several of whom started to investigate the practical possibilities of this laboratory method. The Brenner process, however, proved to be unsatisfactory as a production process in view of the slow rate of deposition, the inconsistent quality of the plate and lack of stability of the solution. It is still being used, however, on a small scale for batch plating by some manufacturing firms⁽⁸⁾. Brenner himself was not impressed by the industrial possibilities of his process, describing it as uneconomical. He was, however, impressed by the properties of the resultant metal coating and directed his attention to the electrodeposition of metals with phosphorus.

At this time, G.A.T.C.[‡] was considering the possibility of electroplating tank cars as a cheaper alternative to the usual nickel-clad construction. The possible advantages that might accrue from a thin, non-porous, uniform nickel coating produced by chemical reduction, led to preliminary investigations and in 1948 a research programme was started with the purpose of developing a practical process for nickel plating large parts by chemical reduction on the basis of large-scale production.

The Brenner method was first tried but gave inconsistent results because of lack of solution stability and did not, in any case, lend itself to production methods. While it might be possible to plate a few hundred watch or instrument parts in a beaker by this method, it was not possible to plate large tank cars or large quantities of components on a continuous three shift system. This problem, which was eventually solved, resulted in an industrial, economic patented process producing a nickel-phosphorus alloy coating now known under the trade mark of "Kanigen". The first pilot plant operated in Chicago in 1952 and two production plants in 1953.

The General American Process

The drawbacks of the Brenner and Riddell method are:—

1. Slow rate of deposition.
2. Lack of stability of the bath.

* Manager, Kanigen Division, Albright and Wilson Ltd.
† 1 mil = 0.001 in. or 25 microns.

‡ General American Transportation Corporation of Chicago.

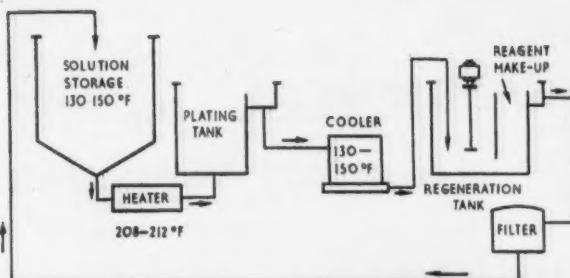


Fig. 1 (left).—Schematic diagram of equipment for maintaining continuous circulation, filtration and regeneration of bath.

Fig. 2 (below).—General view of the Kanigen plant of G.A.T.C. at East Chicago.

3. Dull and rough plating when used for long periods.
4. Relatively high cost owing to short life of the solution.

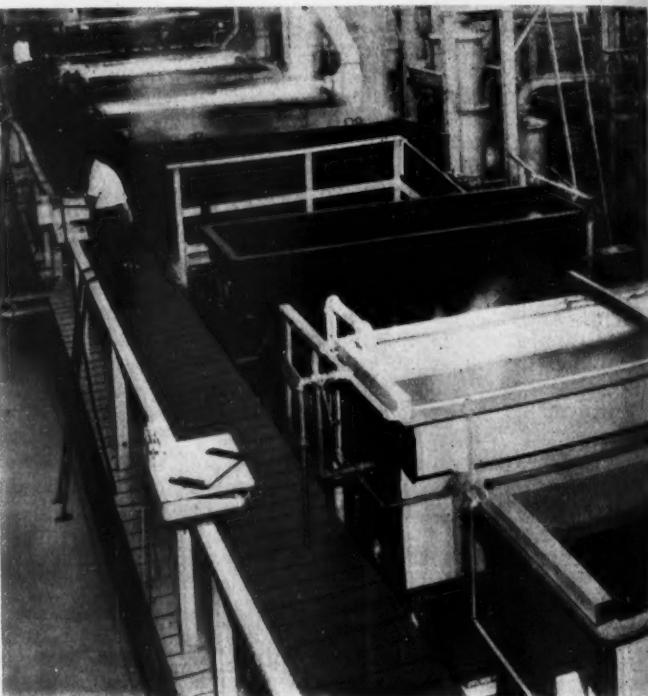
If a chemical plating bath is to be operated in a production plant it is of prime importance to increase the span of useful working life. If the *pH* is kept constant by continuous addition of an alkali, then the phosphite concentration will built up until the threshold of nickel phosphite solubility is reached. It was found that this limit could be raised by the addition of certain nickel complexing compounds. However, if the solution is too stable, little or no plating will take place.

The problem of stability is the most serious in a production plant. Bath decomposition represents a heavy loss in chemicals—parts being plated are rejected and the whole plant has to be shut down for 24 hours or so for cleaning, etc. The first visible sign of decomposition is the appearance of excessive hydrogen and of "black precipitate" which is in itself a large catalytic area. The process is self-accelerating.

It was found that certain inhibitors would counteract this tendency to decomposition.

In addition to the above improvements in solution composition, new principles relating to continuous operation were established which are based on the requirements for catalytic nickel reduction.⁽⁹⁾

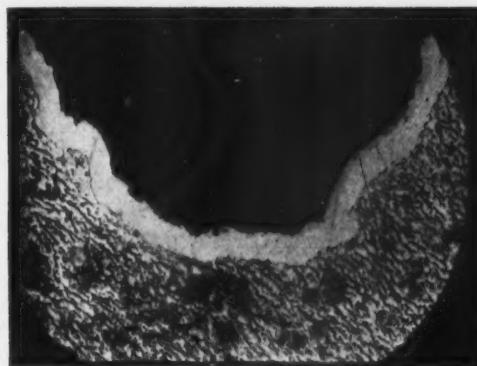
The plating rate is an exponential function of temperature so that the maximum plating rate is obtained at the maximum operating temperature. Further, in order to maintain the optimum plating rate and to control the quality of the plating, it is necessary to feed continuously into the solution the consumable reagents in the form of concentrated solutions. In order to avoid local decomposition resulting in loss of the solution, it is necessary that these addition are made with the solution at



a relatively low temperature^(10, 11). Finally, dust particles can act as catalytic surfaces, resulting in a loss of nickel. Continuous filtration is therefore carried out at comparatively low temperature in order that filter-aid particles do not themselves act as catalytic surfaces.

All these requirements have been incorporated into the G.A.T.C. plating process. Schematically this can be described as shown in Fig. 1^(9, 10, 12).

The plant is designed in such a manner that most of the handling of the solution is done in the cold section. Fig. 2 shows the G.A.T.C. plant at East Chicago, Indiana, which has a plating capacity of 10 to 12 lb. (5 kg.) of Kanigen per hour. (Flow rate 75 gal. per min., approximately 270 litres per min.; bath volume 2,200 gallons, approximately 8,500 litres).



Figs. 3, 4 and 5.—Photomicrographs of sections of Kanigen plate deposited on a threaded surface, showing how the coating follows the contour of the surface of the thread both at root and crest.

In many cases when the interior of a large vessel is to be plated, the plating tank is replaced by the vessel.

The bath can be used until the nickel phosphite begins to precipitate. The solution is then discarded or reclaimed.

The pretreatment of parts for coating by chemical reduction is essentially the same as for electroplating. However, as no electrical equipment is required for plating, soak cleaning methods have been employed. Special techniques have been developed for the deposition of Kanigen on certain metals and alloys.

Chemical Composition, Structure and Physical Properties of Kanigen

A typical Kanigen deposit obtained from the standard acid solution used by G.A.T.C. showed a composition of 91.3 per cent. nickel and 8.7 per cent. phosphorus.

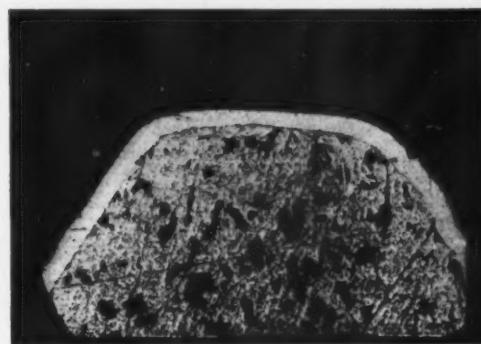
X-ray and electron-diffraction studies have been carried out and the conclusions of one report⁽¹³⁾ are as follows:—

1. Kanigen coatings show the structure as an amorphous, solid substance, with "liquid-like" disorder of the atoms.

2. Different base materials, such as aluminium, brass, steel and Bakelite and different pretreatments of aluminium base have no appreciable influence on the structure of the platings.

3. The deposition of different thicknesses of Kanigen on these base materials has no influence on the amorphous structure of the coating.

The macro-structure, established by optical metallography, showed that in the unetched condition Kanigen plate at a magnification of 1,000 times shows no porosity, channels or other types of void. There was no observable gap between the plate and substrate. The plate followed



the fine contour of the substrate surface in amazing detail (Figs. 3, 4 and 5).

The lack of porosity in Kanigen deposits has been demonstrated by other methods. It has repeatedly shown negative results when immersed in aerated hot (85° C) water for 60 minutes and when submitted to the standard ferroxyl tests. This applies to plating of 0.2 mil. (5 μ) thickness or greater.

When a comparative test of five nickel coatings was carried out by autoradiograph methods,^{(12) (14)} the results were as follows:—

1. Kanigen; 2. Brenner process; 3. Bright nickel;
4. Low pH phosphorus nickel; 5. Watts nickel.

The other important physical properties of Kanigen are as follows:—

Melting point 890° C.

Average electrical resistivity 60 microhm per cm².

Coefficient of linear expansion 13×10^{-6} per °C.

Thermal conductivity 0.0105 to 0.0135 cal. per cm. per sec. per °C.

Average hardness 500 to 550 V.P.N.

Hardness at elevated temperature, particularly

above 350° C, is low and such applications require careful study.

Heat Treatment of Kanigen

The above remarks apply to Kanigen as deposited. At 400° C the deposit transforms to an equilibrium phase mixture of crystallite nickel and nickel phosphide (Ni_3P). Fig. 6 gives heat treatment temperatures and hardness figures typical of those already obtained using a Leitz micro-hardness tester with 100 gm. load.

When Kanigen is heated to 750° C for 5 hours the Ni_3P crystals grow and become dispersed in a regular manner in the nickel matrix and resistance to corrosion is increased as shown in Table I. The corrosion resistance of as-deposited Kanigen is at least equal to and often better than that of wrought nickel. Wherever nickel affords protection against chemical attack, Kanigen plating will do the same. In this respect, it will always be better than electro-deposited nickel of the same thickness, particularly in alkaline media. The rate of attack of 72 per cent. caustic soda at 115° C on Kanigen is 5 to 10 times slower than on pure nickel.

The use of Kanigen in contact with some chemicals is not to be recommended. Rapid failure occurs in chemicals which easily dissolve or complex metallic nickel. The character of the surface is an important factor in corrosion resistance. In general, better surface finishes of the substrate (and therefore of Kanigen) will give better resistance to corrosion.

Mechanical Properties

Kanigen plate has limited elongation. Tensile tests show 3 to 6 per cent. elongation without stress failure. The hardness of the plating gives good

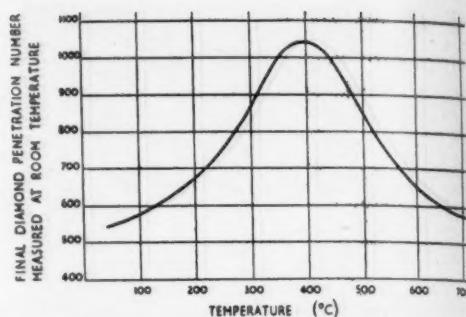


Fig. 6.—Curve showing the effect of heating Kanigen coated cold rolled steel parts in an inert atmosphere to the specified temperature and holding at temperature for 1 hr. Parts were then cooled slowly to 200° C and then removed from the oven. All hardness measurements were made at room temperature on the top surface of plate 5 mils thick.

abrasion resistance if lubrication is used or if the surface temperature is not too high. The only satisfactory test, however, is under service conditions. Comparative tests show wear resistance of as-deposited Kanigen to be between that of hard chromium and electroplated nickel.

The adhesion of Kanigen plate on steel is reported to be of the order of 3 to 6×10^4 lb. per sq. in. and specimens showed no flaking or chipping when tested to destruction in a tensile testing machine. Plated steel bars bent through 180° on a 3-inch diameter mandrel showed no flaking although, because of the high hardness of Kanigen, microscopic cracks appear parallel to the axis of the bend on the outside and compression or shear failure sometimes occurs on the inside of the bend. This

TABLE I

Corrosive Liquid	Temp.	Immersion	Aeration	Test Period in weeks	Penetration in mils per year	
					As-deposited Kanigen	Kanigen heat-treated to 750°C
Glucose	R	T	No	16	None	—
Refinery Brine	R	T	No	23	None	—
Ammonium Hydroxide 30 per cent. NH_3	R	T	No	16	—	0.023
Beer	R	T	No	4	0.217	0.0077
Calcium Chloride 48.5 per cent.	R	T	Yes	20	—	0.011
Citric Acid 5 per cent. ...	R	T	Yes	8	—	0.149
Phosphoric Acid 85 per cent.	R	T	No	16	—	0.160
Sodium Hydroxide 72 per cent.	115° C.	T	Reflux	16	0.069	—
Tanning Solution ...	R	T	No	3	0.048	—

occasionally results in some apparent flaking, but examination has shown that in many cases the separation is within the plating and not between the plating and the substrate. Adhesion on aluminium and alloy steels is good but inferior to that of Kanigen on steel. The adhesion of Kanigen on aluminium is improved by heat treatment at 375° F for one hour. Adhesion on non-metallic materials such as thermosetting plastics is only fair as it depends on adsorption or on dispersed localized bonding.

Comparative tests show that Kanigen had little or no effect on the fatigue life of low-carbon steels. The internal stress of Kanigen is usually compressive of the order of 5,000 lb. per sq. in. Impact and fatigue tests indicate little, if any, hydrogen embrittlement of the basis steel. The as-deposited plating contains about 16 parts per million of hydrogen, but it appears that this hydrogen is not transferred to the basis metal.

Materials Suitable for Plating

Only some metals of the 8th Group of the Periodic System, *viz.*, nickel, palladium, rhodium and ruthenium, are truly catalytic. On the other hand it is possible to deposit nickel on most common metals such as iron, copper, aluminium and its alloys. Graphite and carbon behave like metals. In the case of metals which are below nickel in the electromotive series, such as copper, silver, gold, etc., it is necessary to "initiate" deposition. One method consists in contacting the base metal with a wire or rod of a metal placed above nickel in the electromotive series. This will form an internal voltaic cell which initiates the reaction by the formation of a galvanic nickel nucleus.

Lead, cadmium, tin, bismuth, antimony and zinc cannot be plated. This precludes plating of parts soldered with lead-tin alloys.

Most thermosetting plastics such as Bakelite, polyester and melamine resins, glass, ceramics, balsa wood, etc., can be plated. Special preparation of the base material is required.⁽¹⁵¹⁶⁾

Applications

On metal parts, Kanigen coatings are generally useful as protection against iron contamination, wear or corrosion. Pure nickel has excellent resistance to corrosive attack by many materials. Nickel-phosphorus plating, being mostly nickel, will show at least the same qualities while the phosphorus content adds an extra measure of resistance. This gives nickel-phosphorus plating superior corrosion resistance compared with wrought or electrolytic nickel.

Kanigen plating on steel or aluminium can often replace expensive alloys. Cost savings may be achieved in this way, particularly on parts having intricate contours. Probably the largest field of

application for chemical nickel-phosphorus plating is the prevention of iron contamination. The deposit prevents oxidation of the steel surface which in turn protects the material being handled, *e.g.*, food machinery, etc.

The hardness of Kanigen as-deposited and its heat treatment characteristics make it a useful material for protection against wear. The added benefit of uniformity means that it can easily be applied to hydraulic cylinders, rotating shafts, etc.

In many aircraft applications, Kanigen coating is providing the advantage of a hard, corrosion-resistant surface on aluminium. The uniformity of the coating permits full machining operations prior to coating with no subsequent clean up.

Machinery and equipment manufacturers use hard Kanigen coatings to control wear—and corrosion—on piston rods, crank shafts, printing press beds, ink cylinders, linkages, etc. Valve manufacturers control wear on seal rings with Kanigen. Pump impellers and casings give less erosion trouble when coated.

Kanigen coatings are not recommended for applications where two parts are expected to rub together without lubrication. Galling may result. However, coating is recommended on 300 series stainless steel and type 4100 alloy steels to reduce the galling tendency.

Kanigen deposits can be used as intermediate or bonding layers. A very thin coating of Kanigen on aluminium permits excellent solder adhesion. Tin-lead solders wet the deposit readily if sufficient heat is provided—about 500° F (260° C). Dip tinning of aluminium is very simple once Kanigen coating is applied.

Because of its remarkable uniformity, Kanigen coating may be used to build-up uniformly worn or mismatched parts. For instance, a compressor shaft machined 0.002 in. undersize on the diameter may be coated to a thickness of 0.001 in., bringing the diameter back to the nominal value. Usually, no machining or grinding after coating is required. Similar procedures have been used on pump impellers and housings.

A maximum build-up of no more than 7.0 mils (0.007 in.) is recommended from a cost standpoint. While greater thicknesses are practical, the cost advantage through the elimination of machining after coating may be nullified where very heavy thicknesses are employed.

Limitations

The limitations of Kanigen coatings have been ably summarized by W. J. Crehan⁽¹⁷⁾ as follows:

"It generally is not economical to plate thin steel, thus replacing thin, solid corrosion-resistant alloys.

(Continued on page 277)

ELECTROSTATIC PAINTING

The Ransburg Processes

By RICHARD TILNEY*

(A paper presented at the Spring Conference on "Modern Processes" organized by the Sheet and Strip Metal Users' Technical Association, London, April 25 to 27, 1956)

Introduction

AS a result of the wide experience gained by Ransburg in the field of automatic electrostatic spraying by means of the Ransburg No. 1 Process during the past 10 years and, subsequently, as a result of the use of the original version of the Ransburg No. 2 Process, the last two years have seen still further advances in the techniques of applying the No. 2 Process to an even greater variety of types of work, both from the point of view of improving the flexibility of the Process and the possibility of its application to large surfaces such as complete motor-car bodies.

It is the object of this paper to describe these recent developments in particular but, in the first place, it will be as well to set out the principles of operation of the Ransburg No. 2 Process, all of which apply to these more recent developments. It is assumed that the principles of the Ransburg No. 1 Process are now sufficiently well known and documented to require no further description or explanation.

Principles of Operation of the Ransburg No. 2 Process

The Ransburg No. 2 Process employs an intense electrostatic field, both to atomize the coating material which it is required to apply, and to deposit it on the object to be coated. This is brought about by feeding coating material in a closely controlled and uniform film to a sharp edge maintained at high voltage. It will, therefore, be noted that the use of compressed air in the application of coating materials has been eliminated.

There are two main practical means developed by Ransburg in order to achieve the industrial application of this basic principle of electrostatic atomization and deposition. The original arrangement is that a metallic bell is provided with means for feeding coating material from its centre to the inside of the outer edge of the bell. This edge is relatively sharp and the paint feed is maintained at the required volume by mechanical pumps driven through variable speed gears.

The uniformity of the film of paint fed to the

sharp edge is assured by rotation of the bell at about 900 r.p.m., a speed sufficient in most instances to spread the coating material evenly over the whole interior surface of the bell.

The later development of the process employs a flat metal disc in place of the bell, but the paint feed arrangements, to ensure a controlled flow of paint to the sharp edge of the disc, are identical. In either case, disc and bell are maintained at high voltage from a transformer incorporating full-wave rectification and, naturally, in order to ensure this condition the bell or disc is mounted on an insulating support tube in which an insulating drive shaft is mounted, through which the rotation of the bell or disc already mentioned is provided from a normal electric motor and gearing arrangement.

The parts to be painted are suspended on a conveyor through which they are earthed, running in a line at right-angles to the axis of rotation of the bell or, in the case of the disc, in a loop at whose centre the disc is located. These two conditions are illustrated diagrammatically in Figs. 1 and 2. In either case a powerful electrostatic field is set up between the edge of the bell or disc and the earthed parts suspended from the conveyor and, thus, two unlike poles of an electrostatic field are set up between the paint on the edge of the atomizing unit

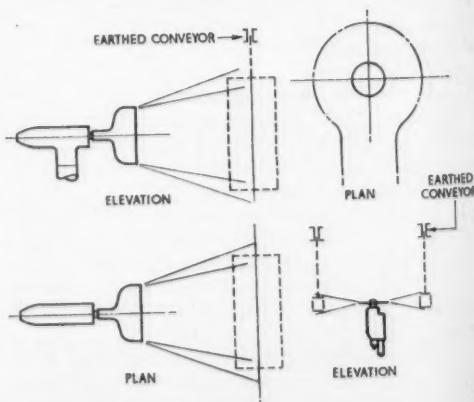
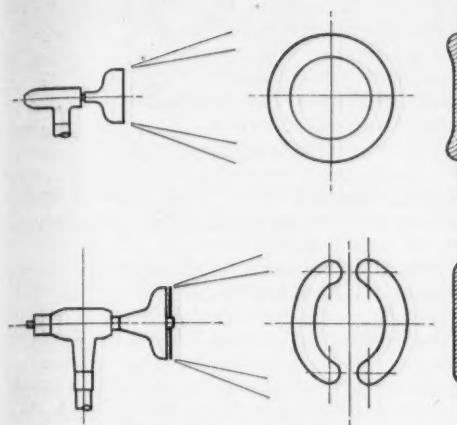


Fig. 1

Fig. 2

* Henry W. Peabody (Industrial) Ltd



Figs. 3 and 4.—The effect of using a bell and a split bell

and the workpieces. The coating material is, therefore, projected from the edge of the atomizing unit at the most concentrated point in the electrostatic field and in process of being so projected is atomized to the finest degree possible. The fineness of atomization is such that particles become invisible a short distance from the atomizing edge and are then carried across the intervening air gap and deposited on the workpiece. The distance between the atomizing edge and the parts to be coated is varied in accordance with a large number of factors, but is, generally speaking, comparable with the distances employed in normal hand-spraying techniques. Various devices and arrangements of multiples of atomizing bells have been used to ensure uniform coating of different sizes and shapes of part since it will be seen from Fig. 3 that from a single bell it is not possible to obtain a uniform film throughout the spray pattern.

The recent developments by Ransburg which form the main subject of this paper have been directed to obviate the complication and relative inflexibility in set-up resulting from this non-uniformity in spray pattern from a single atomizing bell.

Reciprocating-disc Process

A major advance in flexibility of operation of the Ransburg No. 2 Process has been made by the introduction of the reciprocating-disc type of equipment, in which the atomizing disc already described is mounted, together with its drive motor, on a hydraulic reciprocating mechanism, the stroke of which is readily varied to suit the particular workpieces which it is desired to coat. Fig. 5 illustrates this principle; the reciprocating disc provides a uniform spray pattern over the whole of the length of the stroke which is controlled by a simple wall-

mounted control mechanism provided with adjustable limit switches.

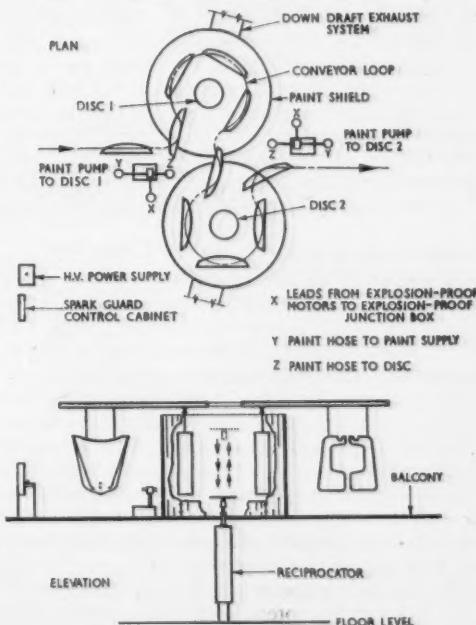
A further major advantage of the reciprocating-disc type of installation is the slow and even build-up of paint film over the surfaces to be coated during their passage round the loop in the conveyor. These loops vary between 4 ft. and 7 ft. in diameter, depending on the size of the parts to be painted, so that the workpiece may be in the painting zone for between one and three minutes, depending on the conveyor speed, during which time the disc may make between 30 and 40 strokes.

This equipment is less sensitive than the bell-type equipment to variations in distance from the edge of the disc to the workpiece and, again, due to the slow build-up of the paint film, substantial variations in paint film thickness can, if necessary, be tolerated without risk of runs or sags.

For large parts at high rates of production, two loops are sometimes provided to ensure effective atomization of large quantities of coating material and also to eliminate in some instances the necessity of indexing all parts so as to paint either side, for example, of sheet-metal pressings or similar components.

For lower conveyor speeds and small components the work may be either rotated or indexed through 90 or 180 degrees, and for even smaller parts the disc may be stationary, either rotating about a vertical axis or on a tilted axis in order to provide a wider

Fig. 5.—Principle of the reciprocating disc process



band width than would be obtained from the stationary horizontal disc.

In the latter case it should be noted that the build-up of the paint film does not take place over the whole of the area of the part throughout the whole length of its passage round the loop but, despite this limitation, the build-up is still considerably slower than in the case of the bell-type installation or of normal production hand-spray methods.

The spacing of the parts on the conveyor is of importance in all applications of the Ransburg No. 2 process. If there is too much space between parts, then build-up will occur on either side of that space, but the distance between parts must be adjusted to ensure any wrap-round required at the edges of parts. For flat sheets the space between parts must be quite small, while on the other hand, large cabinets cannot be conveniently hung closely spaced on a conveyor owing to the clearances required during their passage round corner wheels or if it is necessary to introduce rises or falls in the conveyor run. The loop required for the disc type of application automatically bunches the faces of such parts when being painted, so that the adjustment of the distance between parts becomes very much simpler when using the bell type of equipment.

Split-pattern Bell-type Equipment

As has already been mentioned, a single bell does not produce a uniform paint film owing to the annular ring pattern which it forms, and to obtain such a uniform pattern it is necessary to employ three bells spaced over a distance of between 4 ft. and 5 ft. For the painting of large irregular shaped objects, such as motor-car bodies, this means that the target distance from bell to work cannot be maintained constant by movement of the bell, nor is it practical to use the reciprocating disc and loop type of equipment for such products. To obviate this difficulty, the split-pattern bell has been developed, which is arranged so as to produce a uniform paint pattern from one single atomizing bell.

This uniform paint pattern is ensured by the introduction of an electrode inside the bell which distorts the electrostatic field produced from the edge of the bell. The pattern produced is illustrated in Fig. 4 and the extent of the split between the two halves of the pattern can be adjusted by varying the position of the electrode. It will be seen from this pattern that in quite a short distance a uniform paint film can be built up and, as a result, mechanical movement of the bell can be arranged so as to maintain reasonably uniform target distance from the bell to the work without the difficulties, due to the electrical clearance which must be maintained, which arise if similar movements are applied to the triple-head type equipment.

It will also be noted, as a result of the rapid

build-up of a uniform film, that from the paint formulation point of view Ransburg equipment is now available both for the very slow build-up of paint film as in the case of the reciprocating disc or, should it be required, a rapid build-up by means of the split-pattern bell. This feature is of advantage in the case of some rapid drying materials such as cellulose lacquers, where the finish is spoiled by dusting when the film is built up very slowly unless special precautions are taken in the formulation of coating material.

The application of the split-pattern bell to the finishing of motor-car bodies has already been mentioned and, in amplification of these remarks, it is of interest to note that at rates of production obtaining in Europe adequate film thickness of primer surfacer or of finish coat can be obtained over 80 to 90 per cent. of the surface area of the body, using, at most, five split-pattern bells, one mounted overhead on a hydraulic mechanism for controlling the distance from the bonnet, roof and boot lid of the car and two on either side, a larger bell to coat the lower half or two-thirds of the body and a smaller upper bell to paint the side pillars.

Development work on this particular application shows that the main areas of the body can be completely coated to a high quality of finish using this equipment. The small areas requiring hand fill-in are those where the quality of finish is less important and, in particular, in the case of the primer surfacer where little, if any, flattening of the surface prior to application of the finish coat is normally carried out. In other words, the Ransburg process provides means for the application of a high-quality uniform primed surface which subsequently requires the minimum of hand work prior to application of the finish coat.

Another wide field for the use of the split-pattern bell is in the application of cellulose and other clear lacquers in the finishing of wooden cabinets, particularly television and radio cabinets. This is a quite recent development brought about particularly by close co-operation with certain specialist manufacturers of these lacquers, and which it is hoped will prove of great benefit in reducing the amount of hand polishing required heretofore in the production of a satisfactory standard of finish.

The principles of atomization and deposition of the coating material are identical in the case of the split-pattern bell with those previously described.

Equipment

Apart from the conveyor which it has already been indicated is necessary for the operation of the process, factory regulations in this country require that Ransburg installations should be housed in some form of enclosure which is frequently of light sheet-metal and glass construction and is also provided with a small ventilating plant to evacuate the

solvent vapours. The elimination of over-spray by the use of the process makes the provision of clean make-up air at a controlled temperature an economical method of reducing rejects due to dirt.

The specialized equipment required for a complete installation consists of a high-voltage transformer in which is incorporated full-wave rectification. In this country metal rectifiers are used, whereas in the United States valve-type rectifiers are preferred. The operating voltage can be adjusted in the light of experience to suit the requirements of each particular application but is normally about 90 kV. Primary volts to the transformer are supplied through a control system which limits the high-voltage output to between 2 or 2½ milliamperes. This is done to ensure complete safety to personnel and so that, should a spark occur, it is cold and will not, in normal operating conditions, introduce any risk of fire hazard.

In the control system already mentioned an electronic sparkguard is incorporated and this is adjusted so that, should any parts to be painted approach the high voltage atomizing heads or electrode wires too closely, the complete installation is shut down and cannot be restarted until the fault has been corrected.

Mechanically controlled pumps are provided to ensure uniform and consistent paint supply to the bells or discs and the rate of output from these pumps is readily varied from outside the spraying enclosure.

The conveyor, ventilation system and the paint-feed pumps are all interlocked so as to comply with

current factory regulations and ensure that any failure in operation of the process is immediately brought to the notice of the operating personnel.

With regard to any special requirements in paint formulation which may be desirable in order to obtain the best results from the use of the Ransburg processes, the main considerations concern the fineness of pigments, adequacy of grinding and the exact solvent balance. With the majority of good-quality paints no serious difficulty is experienced in adjusting them to provide entirely satisfactory results.

Adjustment of the paint formulation is, however, sometimes required, but owing to the wide variety of conditions of application as between the use of atomizing bells or discs, it is difficult to generalize on the type of modification called for most frequently. In each case careful laboratory tests are made in conditions reproducing as far as possible those which will be encountered in production and the paints adjusted accordingly.

Conclusion

While the Ransburg processes cannot be applied to every painting problem found in industry, when supplemented by hand touching up of shielded areas the variety of parts which can be satisfactorily painted by use of the processes is extremely wide. Wherever a high-quality finish is required and there is sufficient volume of production to justify conveyorization of the spray shop, it is likely that substantial savings can be obtained by the use either of the Ransburg No. 1 Process or one of the various developments of the Ransburg No. 2 Process.

Deposition of Nickel

(Continued from page 273)

Chemical reduction plating cannot be used on parts which are subsequently welded unless the areas to be welded are masked out. Otherwise a nickel overlay or a line of demarcation between the weld nickel and the plating would be required. Welds made on plated areas may be embrittled by picking up phosphorus from the plating. Since the plating process produces a hard, low ductile coating, it is not suitable plating to use where there will be considerable flexing of the part—such as in forming or drawing operations. All applications necessitating subsequent drawing or forming should be tried out experimentally before specifying nickel plating of any type.

"Chemical reduction plating is not always applicable where heat is encountered, particularly where any rubbing contact exists. The hot hardness is low, so applications involving heat should be investigated for applicability."

If immersion coating (as opposed to flow-through deposition) is required, care must be taken in the design of the part to prevent gas entrapment. If "dead" pockets exist, means for venting them should be provided.

Kanigen can be applied to small parts *en masse* by barrel coating, which is very simple, because no electrical contacts are needed. A good barrel material is melamine.

Economic Considerations

Comparison with electroplating is out of order, because chemical reduction coatings can achieve results in the fields of corrosion protection, hardness and wear resistance which are beyond the possibilities of electroplating. On the other hand, thin deposits obtained by chemical reduction may not supplant decorative electroplating when simple shapes of common metals are involved; but, in the case of complex parts, it often exhibits its greatest advantage.

A comparison of the cost per square foot of special alloys and carbon steel coated with 3 mils of Kanigen

shows that the process is considerably more economical when the base material thickness in inches is beyond $\frac{1}{8}$ in. If, however, the part to be plated is both complex and expensive to fabricate, Kanigen-coated carbon steel may compete favourably with solid corrosion-resistant metals having sections less than $\frac{1}{8}$ in. The above, of course, applies to conditions prevailing at present in the United States of America, and might not be true in other countries.

Much of the information given in the paper is covered by a number of patents and patent applications.

"Kanigen" is the Trade Mark which has been registered by the General American Transportation Corporation in the United States to cover any type of chemical nickel plating performed by, or emanating from, General American Transportation Corporation or its licensees. The same Trade Mark has been registered or filed for registration in other countries.

The work reported in this paper is the result of work carried out by the research department of the General American Transportation Corporation, Chicago, Illinois, and the author has drawn fully upon reports and technical data supplied to him by

that department, particularly the reports of Dr. Gregoire Gutzeit, associate director of the research and development department of the above company, and he wishes to record his appreciation and gratitude for this assistance.

References

- Wurtz, A. *C. r. Acad. des Sciences*, 1844, April 15, **18**, p. 702.
- Breteau, P. *Soc. Chim. Mem.*, 1911, May 10, 89.
- U.S. patent 1,207,218 to Francois Auguste Roux of Paris, France, December, 1916.
- Bach, A. *Ber.*, 1919, November, **42**, p. 4463.
- Brenner, Abner, and Riddell, Grace. *Journ. of Res. of the Natl. Bureau of Standards*, 1946, July, **37**, p. 1725.
- Brenner, Abner, and Riddell, Grace. *Journ. of Res. of the Natl. Bureau of Standards*, 1947, November, **39**, p. 1835.
- U.S. patent 2,532,283 to Abel Brenner and Grace Riddell, December 5, 1950.
- Brenner, A. "Electroless Plating Comes of Age," *Metal Finishing*, 1954, Nov. and Dec., **52** (11 and 12).
- Gutzeit, G., and Landon, R. W. *Plating*, 1954, December.
- U.S. patent 2,658,839 to P. Talmey and W. J. Crehan, issued November 10, 1953 (filed April 12, 1951).
- U.S. patent 2,717,218 to P. Talmey and W. J. Crehan, issued September 6, 1955 (filed July 19, 1952).
- Gutzeit, G. *Metal Progress*, 1954, July.
- Armour Research Foundation of Illinois Institute of Technology, Project No. B-599.
- Wolff, R. H., Henderson, N. A., and Eisler, S. L. *Plating*, 1956, May.
- U.S. patent 2,690,402 to W. J. Crehan, issued September 28, 1954.
- U.S. patents 2,690,401 and 2,690,403 to G. Gutzeit, W. J. Crehan, and A. Krieg, issued September 28, 1954 (filed July 24, 1953).
- Crehan, W. J. *Product Engineering*, 1955, July.

DISCUSSION

Following the presentation of these papers on modern processes they were discussed jointly, as follows:—

Mr. H. SILMAN (Electro-Chemical Engineering Co. Ltd.) said that he hardly liked to say that the process of plating by chemical reduction was competitive with the electro-chemical processes; it was rather supplementary to them. Above all, it should be remembered that the deposit applied by the process described in Mr. Aitken's paper was not a nickel deposit but a deposit which contained a very substantial amount of phosphorus, which in some cases might be a disadvantage. It must be remembered also that in almost all applications of nickel plating one of the most serious problems encountered was that of the brittleness of deposits. This was especially so in bright nickel applications; there had been a constant struggle to evolve bright nickel solutions which would deposit less brittle nickel. The chemically-reduced nickel deposits were admittedly highly brittle, and for many purposes would be absolutely unsuitable. Even bright nickel deposits of the conventional type tended to become brittle under adverse conditions, but they were nothing like so brittle as those described in the paper.

This meant that slight stresses would cause trouble. For example, bright nickel deposits which were reasonably ductile, but not ductile enough, had not been recommended for use in the plating of

bumpers for motor cars, because when bumpers were fitted to a car they were slightly stressed, and that was sufficient to cause surface crazing and cracking of the nickel, which could result in serious rusting of the underlying metal. The amount of flexing in a bumper might be thought to be very small indeed and hardly noticeable, but it was sufficient to make it necessary for almost everyone who produced bumpers to use a semi-matt or matt deposit.

There should not be undue optimism, therefore, about the use of the chemical reduction process where corrosion resistance was required and parts were expected to be stressed, because it was well known that phosphorus in these metals tended to embrittle them, and it was extremely difficult to avoid that when using the process which had been described. Perhaps the author would say a little more about the critical properties of the deposits in relation to their corrosion resistance and behaviour under stress.

Mr. B. E. BUNCE (Gillette Industries Ltd.) said he had been most interested to read Mr. Aitken's paper, as his own company had been carrying out work on this subject for about two years. There was a number of points in the paper with which he would like to deal. For example, the drawbacks of the Brenner/Riddell method were given. He did not necessarily agree with those points, since some of the solutions mentioned in the Brenner/Riddell report gave a fairly high rate of deposition; in fact,

one process gave about 0.001 in. per hour. Moreover, in his experience some of the solutions were comparatively stable and would give bright deposits, particularly the one which used sodium glycolate as a buffer.

With regard to the mechanical properties of the Kanigen plate, he had found that the elongation, without stress failure, of deposits was much lower than the stated values of 3 to 6 per cent., being more like 1 per cent., lower than for the bright nickel electrodeposit, which gave values around 2.5 per cent., and cobalt-nickel, which gave values of about 4.5 per cent. An attempt had also been made to plate aluminium by this method in the way mentioned in one of the Kanigen patents, but the results were not very good.

With regard to corrosion protection, the electroless nickel gave rather better results than cobalt-nickel electrodeposits and ordinary bright nickel electrodeposits, in that order. On welding the electroless deposit, difficulty had been experienced on an experimental job carried out for another company, due to the lower melting point compared with ordinary electro-plated nickel.

He had noted in the literature, and again in the present paper, the emphasis on the economic comparison with electro-plating being out of order. His company had developed a method which made it definitely economic for decorative purposes, mainly by virtue of the fact that it was possible greatly to simplify the jigging for some components.

For example, a standard plating jig for razor guards, constructed of polythene-covered brass, lasted about one week before it required stripping and recovering with polythene. An electroless jig however carried 100 components, instead of 16 in the other case; it was constructed of modified phenolic-resin-bonded fibre glass tubing, and experience had shown that it was practically indestructible.

The process which was being used was slightly limited in that it was found that a bright deposit could be obtained only on single-phase alloys (in their case 70/30 brass), while alloys of two phases or more, such as 60/40 and 60/40 leaded brass, gave only semi-bright deposits and complete coverage was more difficult than with the 70/30 brass.

A number of the solutions suggested in the literature had been tried; a solution containing nickel sulphate, 24 gm. per litre, sodium hypophosphite, 24 gm. per litre, and sodium lactate, 20 gm. per litre, gave very good results with a deposit of up to 0.0008 in. per hr., with a pH of 4.5 at 90° C. Sodium lactate was a readily available commercial chemical. This solution had been used for barrel plating with some success, in a high-temperature Perspex barrel.

The nickel-sulphate bath was not in use at the

present time, an attempt was being made to find a solution in which the pH change was much less during working. The nickel sulphate had been replaced by nickel acetate, which produced acetic acid and, that being volatile, it tended to be driven off at the working temperature. It was also weakly dissociated in solution, so that only a slight pH change occurred, which for small-scale processes was a distinct advantage. So far about 1,700 sq. ft. of components, about 2,000 at a time, had been plated with a deposit of 0.0002 in. in a 50-gallon tank. This solution again had a rate of deposition of about 0.0008 in. per hr.

Mr. Bunce said that he would like to hear the author's views on the type of material which he considered suitable for constructing tanks for the Kanigen solution. He had tried a second-grade vitreous enamel without success; a first-grade acid-resistant material was considered to be much too expensive. Polyester resin and modified phenolic resin glass fibre tanks had been found unsuitable owing to blistering at the working temperature. A heat-cured epoxy resin glass fibre tank, which seemed to be standing up very well, was now being used.

Mr. R. W. DE VERE STACPOOLE (Gillette Industries Ltd.) said that Mr. Tilney had shown some very interesting examples of the spraying of large articles, but there was the question of its application to small articles, and he was thinking in particular of strip metal. Was it possible to get a thin coating, and what uniformity of coating would be obtained? If strip was passed by a large spray gun, it seemed to him that it would be necessary to run the strip at a very high speed, and that might perhaps lead to lack of uniformity; however, the high speed would be necessary to get the thin coating which would probably be thinner than that applied to car bodies, for instance.

Reference was made in the paper to the fire hazard, and he found it puzzling to find it stated that a spark could be tolerated. In an inflammable atmosphere, if there was any spark at all, it would be expected that a fire would start.

Mr. R. TILNEY said that the answer was not to let the atmosphere become inflammable; further, the spark was cold. Continuing, he said that in the first place the atmosphere was not allowed to reach an explosive condition, because there was sufficient ventilation to remove the vapours as they were formed. An advantage of the process which he had not mentioned when speaking earlier was that the reduction in the volume of air which had to be extracted was, roughly speaking, 90 per cent. by comparison with what was required for hand spraying. For small parts that did not mean much, but for large ones it meant a great deal.

The current of the high voltage output was limited to about 2 m/a., and the spark was in fact

cold, i.e., it would not burn one's finger. Experiments were carried out for the Ministry of Supply for another type of application altogether, using a very sensitive detonator powder, and after keeping the spark playing on the powder for about twenty minutes, it failed to go off, which could be taken as a reasonable standard of safety. At the same time, he agreed that there might be trouble if the parts came through very hot from some previous process. The only fires which had ever occurred had been due to parts coming through almost at or even above the flash-point of the solvents in the paint, and then it required only the least spark to cause trouble; but that was not a normal operating condition.

Mr. R. WALL (Associated Automation Co. Ltd.) referred to what Mr. Tilney had said about the painting of door frames, which had been painted at the rate of 36 to the gallon by normal methods, while by his methods the figure had gone up to 170 to the gallon. To ask the obvious question, presumably the thickness of the paint film was the same in each case; it did not mean that the usage of paint had been reduced to 20 per cent. simply as a result of applying only 20 per cent. of the paint thickness. The parts shown were relatively small, but Mr. Tilney had then shown pictures of a motor-car body being sprayed. Would the figures which he had quoted for the small parts apply also to the bigger products?

Mr. CROSS (Austin Motor Co. Ltd.), also referring to Mr. Tilney's picture of a motor-car body, said he would be interested to know whether or not parts of the body such as the rear shoulders, etc., were painted to the same thickness as the side panels. He also asked whether the voltages used were the same as those used in the normal electrostatic spraying for wheels and articles of that type, and also how Mr. Tilney proposed to paint under the sills of the body with a bell which basically pointed directly at the side of it. The underneath sill had to be painted, and there did not seem to be any real coverage of that part of the motor-car body.

Mr. R. WALL then asked Mr. Aitken and the two speakers who had followed him whether they could give any information on the following question. His company had tried the process, but only on a laboratory scale, on the basis of information published in the *Nickel Bulletin*, using the sulphate and nickel-chloride solutions. They had obtained, however, much better control from the nickel chloride-hypophosphite solution. He thought that the engineering application of the process was competitive with electroplating, but not with electroplating in the decorative sense. The components which he had in mind were those, for example, in carbon steel, mild steel and brass, which were used in counting machines, electronic devices, adding machines, etc. A particular application which had

been tried concerned very small parts which were cyanide case-hardened to give a case of approximately 0.001 in. These very light mechanisms had to be plated afterwards for resistance to corrosion. Cadmium plating was currently being used, but care had to be taken about the amount deposited because of the scuffing up of the parts on light mechanisms of this type.

He felt that the above was a typical engineering application for the Kanigen process, and it was envisaged that the parts could be plated in large quantities and that the cyanide treatment could be dispensed with, because a hardness of up to 1,000 V.P.N. could be obtained. The same applied to component parts which were now rhodium plated, such as pinions, to give a hard deposit, and to some which were chromium plated. The biggest difficulty was one which was known to all electroplaters and others concerned with electrodeposition, namely, the points of high current density. With the electroless process this problem was completely eliminated, and the use of expensive solutions, e.g., for rhodium plating, was avoided.

A MEMBER asked whether nickel plated chemically could be polished, and whether it could be chromium plated satisfactorily.

Mr. AITKEN said that the answer was in the affirmative. Normally they would recommend polishing the substrate material, which was usually more easily worked. The same surface finish would be obtained on the nickel coating.

Mr. R. TILNEY said that he had not dealt with small parts because the later developments in the Ransburg process had primarily been concerned with making the No. 2 process more applicable to large parts. He had shown a photograph, however, of a stationary disc which was treating motor-car speedometer valances. That type of unit could be used or, alternatively, a single bell could be used to deal with quite small parts. There was one plant operating in this country which lacquered lipstick cases and pencil tops at the rate of about 15,000 per hr.

The important point of the thickness of the film coating had been raised. That was controllable within very wide limits by the process, because the paint was fed at a predetermined speed through a pump the speed of which could be varied in relation to the speed of the conveyor and the thinness of the coat to be applied. This matter was in the hands of the paint manufacturer who was concerned with it because it was a question of the thinness of the coat which would give a satisfactory surface after it had been stoved or received any further treatment required. To speak more specifically, it was possible to apply plain primer coats of 0.0005 in. thickness and deposits up to 0.002 to 0.003 in. Those were about the limits, but they depended

ch were
pproximate-
ms had
rrosion.
ed, but
posited
in light

neering
it was
n large
ould be
o 1,000
lied to
plated,
o some
fficulty
ers and
namely,
th the
completely
olutions,

nically
omium

in the
mmend
usually
finish

at with
in the
cerned
able to
ever,
or-car
ould be
sed to
plant
stick
5,000

the film
e film
llable
e the
ough a
ation
of the
ands of
ith it
e coat
t had
ment
was
5 in.
3 in.
nded

rather more on the coating material than on the method of application.

The next question concerned the economy to be realized. As a rough guide, on large flat surfaces such as refrigerators and motor-car bodies the economy to be obtained was about 50 per cent. compared with hand spraying. That meant 50 per cent. of the equivalent hand spraying, because with a motor-car body there was also the inside to be painted. For the outside surface, however, 50 per cent. was a reasonable figure. A man who was doing hand spraying must be very good if he threw no more than half of what he sprayed away. At the other end of the scale, with small parts, it was not unreasonable to expect economies of 80 per cent. and even higher. He had spoken to someone recently who wanted to spray small pieces of wire and who admitted that the process would save 90 per cent., although in this case the previous total consumption was not great.

It was true that if a particular part of a motor-car body was nearer the atomizing heads than other parts it would tend to get overloaded with paint, but the form of a motor-car body worked out rather well. In the first place, a fair amount of compensation for this feature could be achieved by the proper positioning of the atomizing heads. Either the heads were taken away slightly from the prominent parts or pushed towards the more difficult sections to be coated. Fortunately, the prominent parts of a motor-car body happened to be the parts which were more worked in the metal-working processes and therefore tended to have a slightly worse surface on them than the relatively unworked sheet metal, which remained in much the same quality as that which it had when coming from the steel mill, so that a slightly heavier deposit was required of the filler and priming coats to cover up metal defects. That was a factor which worked in the process's favour instead of, as with most engineering problems, going the other way.

The voltage at which the process was operated was virtually the same as for the No. 1 process, but it was usually spoken of as being 90 kV. instead of 130 kV. for the No. 1, the reason being that the No. 1 process depended on the peak voltage, and used a half-wave rectifier whereas the No. 2 required full-wave rectification, the mean voltage being about 90 kV. In the case of the motor-car body spraying operation, on which he had laid some emphasis, a rather higher voltage was used in order to get good atomization of the particular paints used, which had to be atomized at a high rate. The higher the voltage the greater was the amount of paint which could be atomized from a given size of bell.

Returning to the question of small parts, the illustrations which he had shown depicted relatively

large bells, but they were available in all sizes down to a diameter of 1 in. The amount of paint which could be atomized with a 1-in. bell was, of course, fairly restricted.

The point had been raised about the spraying of the undersill of the motor-car body. So far in this country it had not been found that the turn-round was sufficiently great to need anything more than the natural wrap-round effect of the electrostatic field, and an adequate coating right round was obtained, in the same way as in the case of the door and the windscreen openings there was wrap-round on the pillars and into the inner side of the door and through the window. The wrap-round was very substantial and took the outer coating well into the car, where it could be married up to the internal spraying, which had to be done, of course, by hand. In the U.S.A., where there were rather heavier rounds to the undersill, some special supplementary throwing electrode devices were used to get a little more underneath.

Mr. A. McL. AITKEN, dealing with the competition of chemical reduction with electrodeposited nickel, said he had talked to electroplaters in seven countries in the last twelve months, and they had always asked him how much the chemical reduction process cost. His reply had been "How much does yours cost?" and then they backed away. He had taken a bicycle handlebar to two plating shops in Copenhagen; one had quoted him 1s. 6d. and the other 9s. There had been no guarantee that the work done for the 9s. would be any better than that done for the 1s. 6d. It had been shown that afternoon that there were certain applications for which chemical reduction might be cheaper than electroplating and other applications where it would not be as cheap.

His company had maintained that comparisons with electroplating were out of order because they had always considered the chemical plating of components which were difficult to electroplate. Most components which were given decorative plating today had been designed as far as possible to make electroplating easy. His company were very pleased, however, to find enthusiasm for the competitive nature of the chemical reduction process, and in fact had designed a special bath solution for decorative plating because of the demands made on them.

Mr. Silman was right to talk about the brittleness and lack of ductility of the plate. Mr. Aitken was surprised, however, to hear from Mr. Bunce that he had obtained only 1 per cent. elongation. Elongation figures had been checked by the Atomic Energy Authority who at first gave a figure of 9 per cent., but on being asked to check found that with alu-

(continued on page 284)

shows that the process is considerably more economical when the base material thickness in inches is beyond $\frac{1}{8}$ in. If, however, the part to be plated is both complex and expensive to fabricate, Kanigen-coated carbon steel may compete favourably with solid corrosion-resistant metals having sections less than $\frac{1}{8}$ in. The above, of course, applies to conditions prevailing at present in the United States of America, and might not be true in other countries.

Much of the information given in the paper is covered by a number of patents and patent applications.

"Kanigen" is the Trade Mark which has been registered by the General American Transportation Corporation in the United States to cover any type of chemical nickel plating performed by, or emanating from, General American Transportation Corporation or its licensees. The same Trade Mark has been registered or filed for registration in other countries.

The work reported in this paper is the result of work carried out by the research department of the General American Transportation Corporation, Chicago, Illinois, and the author has drawn fully upon reports and technical data supplied to him by

that department, particularly the reports of Dr. Gregoire Gutzeit, associate director of the research and development department of the above company, and he wishes to record his appreciation and gratitude for this assistance.

References

- (1) Wurtz, A. *C. R. Acad. des Sciences*, 1844, April 15, **18**, p. 702.
- (2) Breteau, P. *Soc. Chim. Mem.*, 1911, May 10, 89.
- (3) U.S. patent 1,207,218 to Francois Auguste Roux of Paris, France, December, 1916.
- (4) Bach, A. *Ber.*, 1919, November, **42**, p. 4463.
- (5) Brenner, Abner, and Riddell, Grace. *Journ. of Res. of the Nat'l. Bureau of Standards*, 1946, July, **37**, p. 1725.
- (6) Brenner, Abner, and Riddell¹, Grace. *Journ. of Res. of the Nat'l. Bureau of Standards*, 1947, November, **39**, p. 1835.
- (7) U.S. patent 2,532,283 to Abel Brenner and Grace Riddell, December 5, 1950.
- (8) Brenner, A. "Electroless Plating Comes of Age," *Metal Finishing*, 1954, Nov. and Dec., **52** (11 and 12).
- (9) Gutzeit, G. and Landon, R. W. *Plating*, 1954, December.
- (10) U.S. patent 2,658,839 to P. Talmy and W. J. Crehan, November 10, 1953 (filed April 12, 1951).
- (11) U.S. patent 2,717,218 to P. Talmy and W. J. Crehan, issued September 6, 1955 (filed July 19, 1952).
- (12) Gutzeit, G. *Metal Progress*, 1954, July.
- (13) Armour Research Foundation of Illinois Institute of Technology, Project No. B-599.
- (14) Wolff, R. H., Henderson, N. A., and Eisler, S. L. *Plating*, 1956, May.
- (15) U.S. patent 2,690,402 to W. J. Crehan, issued September 28, 1954.
- (16) U.S. patents 2,690,401 and 2,690,403 to G. Gutzeit, W. J. Crehan, and A. Krieg, issued September 28, 1954 (filed July 24, 1953).
- (17) Crehan, W. J. *Product Engineering*, 1955, July.

DISCUSSION

Following the presentation of these papers on modern processes they were discussed jointly, as follows:-

Mr. H. SILMAN (Electro-Chemical Engineering Co. Ltd.) said that he hardly liked to say that the process of plating by chemical reduction was competitive with the electro-chemical processes; it was rather supplementary to them. Above all, it should be remembered that the deposit applied by the process described in Mr. Aitken's paper was not a nickel deposit but a deposit which contained a very substantial amount of phosphorus, which in some cases might be a disadvantage. It must be remembered also that in almost all applications of nickel plating one of the most serious problems encountered was that of the brittleness of deposits. This was especially so in bright nickel applications; there had been a constant struggle to evolve bright nickel solutions which would deposit less brittle nickel. The chemically-reduced nickel deposits were admittedly highly brittle, and for many purposes would be absolutely unsuitable. Even bright nickel deposits of the conventional type tended to become brittle under adverse conditions, but they were nothing like so brittle as those described in the paper.

This meant that slight stresses would cause trouble. For example, bright nickel deposits which were reasonably ductile, but not ductile enough, had not been recommended for use in the plating of

bumpers for motor cars, because when bumpers were fitted to a car they were slightly stressed, and that was sufficient to cause surface crazing and cracking of the nickel, which could result in serious rusting of the underlying metal. The amount of flexing in a bumper might be thought to be very small indeed and hardly noticeable, but it was sufficient to make it necessary for almost everyone who produced bumpers to use a semi-matt or matt deposit.

There should not be undue optimism, therefore, about the use of the chemical reduction process where corrosion resistance was required and parts were expected to be stressed, because it was well known that phosphorus in these metals tended to embrittle them, and it was extremely difficult to avoid that when using the process which had been described. Perhaps the author would say a little more about the critical properties of the deposits in relation to their corrosion resistance and behaviour under stress.

Mr. B. E. BUNCE (Gillette Industries Ltd.) said he had been most interested to read Mr. Aitken's paper, as his own company had been carrying out work on this subject for about two years. There was a number of points in the paper with which he would like to deal. For example, the drawbacks of the Brenner/Riddell method were given. He did not necessarily agree with those points, since some of the solutions mentioned in the Brenner/Riddell report gave a fairly high rate of deposition; in fact,

one process gave about 0.001 in. per hour. Moreover, in his experience some of the solutions were comparatively stable and would give bright deposits, particularly the one which used sodium glycolate as a buffer.

With regard to the mechanical properties of the Kanigen plate, he had found that the elongation, without stress failure, of deposits was much lower than the stated values of 3 to 6 per cent., being more like 1 per cent., lower than for the bright nickel electrodeposit, which gave values around 2.5 per cent., and cobalt-nickel, which gave values of about 4.5 per cent. An attempt had also been made to plate aluminium by this method in the way mentioned in one of the Kanigen patents, but the results were not very good.

With regard to corrosion protection, the electroless nickel gave rather better results than cobalt-nickel electrodeposits and ordinary bright nickel electrodeposits, in that order. On welding the electroless deposit, difficulty had been experienced on an experimental job carried out for another company, due to the lower melting point compared with ordinary electro-plated nickel.

He had noted in the literature, and again in the present paper, the emphasis on the economic comparison with electro-plating being out of order. His company had developed a method which made it definitely economic for decorative purposes, mainly by virtue of the fact that it was possible greatly to simplify the jigging for some components.

For example, a standard plating jig for razor guards, constructed of polythene-covered brass, lasted about one week before it required stripping and recovering with polythene. An electroless jig however carried 100 components, instead of 16 in the other case; it was constructed of modified phenolic-resin-bonded fibre glass tubing, and experience had shown that it was practically indestructible.

The process which was being used was slightly limited in that it was found that a bright deposit could be obtained only on single-phase alloys (in their case 70/30 brass), while alloys of two phases or more, such as 60/40 and 60/40 leaded brass, gave only semi-bright deposits and complete coverage was more difficult than with the 70/30 brass.

A number of the solutions suggested in the literature had been tried; a solution containing nickel sulphate, 24 gm. per litre, sodium hypophosphite, 24 gm. per litre, and sodium lactate, 20 gm. per litre, gave very good results with a deposit of up to 0.0008 in. per hr., with a pH of 4.5 at 90° C. Sodium lactate was a readily available commercial chemical. This solution had been used for barrel plating with some success, in a high-temperature Perspex barrel.

The nickel-sulphate bath was not in use at the

present time, an attempt was being made to find a solution in which the pH change was much less during working. The nickel sulphate had been replaced by nickel acetate, which produced acetic acid and, that being volatile, it tended to be driven off at the working temperature. It was also weakly dissociated in solution, so that only a slight pH change occurred, which for small-scale processes was a distinct advantage. So far about 1,700 sq. ft. of components, about 2,000 at a time, had been plated with a deposit of 0.0002 in. in a 50-gallon tank. This solution again had a rate of deposition of about 0.0008 in. per hr.

Mr. Bunce said that he would like to hear the author's views on the type of material which he considered suitable for constructing tanks for the Kanigen solution. He had tried a second-grade vitreous enamel without success; a first-grade acid-resisting material was considered to be much too expensive. Polyester resin and modified phenolic resin glass fibre tanks had been found unsuitable owing to blistering at the working temperature. A heat-cured epoxy resin glass fibre tank, which seemed to be standing up very well, was now being used.

Mr. R. W. DE VERE STACPOOLE (Gillette Industries Ltd.) said that Mr. Tilney had shown some very interesting examples of the spraying of large articles, but there was the question of its application to small articles, and he was thinking in particular of strip metal. Was it possible to get a thin coating, and what uniformity of coating would be obtained? If strip was passed by a large spray gun, it seemed to him that it would be necessary to run the strip at a very high speed, and that might perhaps lead to lack of uniformity; however, the high speed would be necessary to get the thin coating which would probably be thinner than that applied to car bodies, for instance.

Reference was made in the paper to the fire hazard, and he found it puzzling to find it stated that a spark could be tolerated. In an inflammable atmosphere, if there was any spark at all, it would be expected that a fire would start.

Mr. R. TILNEY said that the answer was not to let the atmosphere become inflammable; further, the spark was cold. Continuing, he said that in the first place the atmosphere was not allowed to reach an explosive condition, because there was sufficient ventilation to remove the vapours as they were formed. An advantage of the process which he had not mentioned when speaking earlier was that the reduction in the volume of air which had to be extracted was, roughly speaking, 90 per cent. by comparison with what was required for hand spraying. For small parts that did not mean much, but for large ones it meant a great deal.

The current of the high voltage output was limited to about 2 m/a., and the spark was in fact

cold, *i.e.*, it would not burn one's finger. Experiments were carried out for the Ministry of Supply for another type of application altogether, using a very sensitive detonator powder, and after keeping the spark playing on the powder for about twenty minutes, it failed to go off, which could be taken as a reasonable standard of safety. At the same time, he agreed that there might be trouble if the parts came through very hot from some previous process. The only fires which had ever occurred had been due to parts coming through almost at or even above the flash-point of the solvents in the paint, and then it required only the least spark to cause trouble; but that was not a normal operating condition.

Mr. R. WALL (Associated Automation Co. Ltd.) referred to what Mr. Tilney had said about the painting of door frames, which had been painted at the rate of 36 to the gallon by normal methods, while by his methods the figure had gone up to 170 to the gallon. To ask the obvious question, presumably the thickness of the paint film was the same in each case; it did not mean that the usage of paint had been reduced to 20 per cent. simply as a result of applying only 20 per cent. of the paint thickness. The parts shown were relatively small, but Mr. Tilney had then shown pictures of a motor-car body being sprayed. Would the figures which he had quoted for the small parts apply also to the bigger products?

Mr. CROSS (Austin Motor Co. Ltd.), also referring to Mr. Tilney's picture of a motor-car body, said he would be interested to know whether or not parts of the body such as the rear shoulders, etc., were painted to the same thickness as the side panels. He also asked whether the voltages used were the same as those used in the normal electrostatic spraying for wheels and articles of that type, and also how Mr. Tilney proposed to paint under the sills of the body with a bell which basically pointed directly at the side of it. The underneath sill had to be painted, and there did not seem to be any real coverage of that part of the motor-car body.

Mr. R. WALL then asked Mr. Aitken and the two speakers who had followed him whether they could give any information on the following question. His company had tried the process, but only on a laboratory scale, on the basis of information published in the *Nickel Bulletin*, using the sulphate and nickel-chloride solutions. They had obtained, however, much better control from the nickel chloride-hypophosphite solution. He thought that the engineering application of the process was competitive with electroplating, but not with electroplating in the decorative sense. The components which he had in mind were those, for example, in carbon steel, mild steel and brass, which were used in counting machines, electronic devices, adding machines, etc. A particular application which had

been tried concerned very small parts which were cyanide case-hardened to give a case of approximately 0.001 in. These very light mechanisms had to be plated afterwards for resistance to corrosion. Cadmium plating was currently being used, but care had to be taken about the amount deposited because of the scuffing up of the parts on light mechanisms of this type.

He felt that the above was a typical engineering application for the Kanigen process, and it was envisaged that the parts could be plated in large quantities and that the cyanide treatment could be dispensed with, because a hardness of up to 1,000 V.P.N. could be obtained. The same applied to component parts which were now rhodium plated, such as pinions, to give a hard deposit, and to some which were chromium plated. The biggest difficulty was one which was known to all electroplaters and others concerned with electrodeposition, namely, the points of high current density. With the electroless process this problem was completely eliminated, and the use of expensive solutions, *e.g.*, for rhodium plating, was avoided.

A MEMBER asked whether nickel plated chemically could be polished, and whether it could be chromium plated satisfactorily.

Mr. AITKEN said that the answer was in the affirmative. Normally they would recommend polishing the substrate material, which was usually more easily worked. The same surface finish would be obtained on the nickel coating.

Mr. R. TILNEY said that he had not dealt with small parts because the later developments in the Ransburg process had primarily been concerned with making the No. 2 process more applicable to large parts. He had shown a photograph, however, of a stationary disc which was treating motor-car speedometer valances. That type of unit could be used or, alternatively, a single bell could be used to deal with quite small parts. There was one plant operating in this country which lacquered lipstick cases and pencil tops at the rate of about 15,000 per hr.

The important point of the thickness of the film coating had been raised. That was controllable within very wide limits by the process, because the paint was fed at a predetermined speed through a pump the speed of which could be varied in relation to the speed of the conveyor and the thinness of the coat to be applied. This matter was in the hands of the paint manufacturer who was concerned with it because it was a question of the thinness of the coat which would give a satisfactory surface after it had been stoved or received any further treatment required. To speak more specifically, it was possible to apply plain primer coats of 0.0005 in. thickness and deposits up to 0.002 to 0.003 in. Those were about the limits, but they depended

rather more on the coating material than on the method of application.

The next question concerned the economy to be realized. As a rough guide, on large flat surfaces such as refrigerators and motor-car bodies the economy to be obtained was about 50 per cent. compared with hand spraying. That meant 50 per cent. of the equivalent hand spraying, because with a motor-car body there was also the inside to be painted. For the outside surface, however, 50 per cent. was a reasonable figure. A man who was doing hand spraying must be very good if he threw no more than half of what he sprayed away. At the other end of the scale, with small parts, it was not unreasonable to expect economies of 80 per cent. and even higher. He had spoken to someone recently who wanted to spray small pieces of wire and who admitted that the process would save 90 per cent., although in this case the previous total consumption was not great.

It was true that if a particular part of a motor-car body was nearer the atomizing heads than other parts it would tend to get overloaded with paint, but the form of a motor-car body worked out rather well. In the first place, a fair amount of compensation for this feature could be achieved by the proper positioning of the atomizing heads. Either the heads were taken away slightly from the prominent parts or pushed towards the more difficult sections to be coated. Fortunately, the prominent parts of a motor-car body happened to be the parts which were more worked in the metal-working processes and therefore tended to have a slightly worse surface on them than the relatively unworked sheet metal, which remained in much the same quality as that which it had when coming from the steel mill, so that a slightly heavier deposit was required of the filler and priming coats to cover up metal defects. That was a factor which worked in the process's favour instead of, as with most engineering problems, going the other way.

The voltage at which the process was operated was virtually the same as for the No. 1 process, but it was usually spoken of as being 90 kV. instead of 130 kV. for the No. 1, the reason being that the No. 1 process depended on the peak voltage, and used a half-wave rectifier whereas the No. 2 required full-wave rectification, the mean voltage being about 90 kV. In the case of the motor-car body spraying operation, on which he had laid some emphasis, a rather higher voltage was used in order to get good atomization of the particular paints used, which had to be atomized at a high rate. The higher the voltage the greater was the amount of paint which could be atomized from a given size of bell.

Returning to the question of small parts, the illustrations which he had shown depicted relatively

large bells, but they were available in all sizes down to a diameter of 1 in. The amount of paint which could be atomized with a 1-in. bell was, of course, fairly restricted.

The point had been raised about the spraying of the undersill of the motor-car body. So far in this country it had not been found that the turn-round was sufficiently great to need anything more than the natural wrap-round effect of the electrostatic field, and an adequate coating right round was obtained, in the same way as in the case of the door and the windscreens openings there was wrap-round on the pillars and into the inner side of the door and through the window. The wrap-round was very substantial and took the outer coating well into the car, where it could be married up to the internal spraying, which had to be done, of course, by hand. In the U.S.A., where there were rather heavier rounds to the undersill, some special supplementary throwing electrode devices were used to get a little more underneath.

Mr. A. MCL. AITKEN, dealing with the competition of chemical reduction with electrodeposited nickel, said he had talked to electroplaters in seven countries in the last twelve months, and they had always asked him how much the chemical reduction process cost. His reply had been "How much does yours cost?" and then they backed away. He had taken a bicycle handlebar to two plating shops in Copenhagen; one had quoted him 1s. 6d. and the other 9s. There had been no guarantee that the work done for the 9s. would be any better than that done for the 1s. 6d. It had been shown that afternoon that there were certain applications for which chemical reduction might be cheaper than electroplating and other applications where it would not be as cheap.

His company had maintained that comparisons with electroplating were out of order because they had always considered the chemical plating of components which were difficult to electroplate. Most components which were given decorative plating today had been designed as far as possible to make electroplating easy. His company were very pleased, however, to find enthusiasm for the competitive nature of the chemical reduction process, and in fact had designed a special bath solution for decorative plating because of the demands made on them.

Mr. Silman was right to talk about the brittleness and lack of ductility of the plate. Mr. Aitken was surprised, however, to hear from Mr. Bunce that he had obtained only 1 per cent. elongation. Elongation figures had been checked by the Atomic Energy Authority who at first gave a figure of 9 per cent., but on being asked to check found that with alu-

(continued on page 284)

THE BELGIAN CORROSION RESEARCH CENTRE

THE Centre Belge d'Etude de la Corrosion, now more generally known by its initials as CEBELCOR, is a non-profit-making Association of an international character, devoted to combating the losses caused to industry by corrosion in all its forms. This aim is pursued on three levels, research, technical development and instruction.

Members of the Association at present number 64, 51 of whom are in Belgium and the remainder in Australia, France, Italy, the Netherlands, Portugal, Spain and the U.S.A.

The Association is unique in its single-minded devotion to the cause of corrosion prevention and we present below a brief review of some of its activities in the last two years based on information provided by the director, Mons. M. Pourbaix; it is hoped to publish further notes on the work of CEBELCOR at regular intervals in the future.

Research Activities

With the help of the Institute for the Promotion of Scientific Research in Industry and Agriculture (I.R.S.I.A.) and the Union Minière du Haut Katanga, the Association has been able to institute a research programme, in particular fundamental research on the electro-chemical behaviour of metals and metalloids, especially directed towards the following ends:

1. Compilation of an atlas of electrochemical equilibrium conditions.
2. Publication of standard tables of free enthalpies of formation.
3. Publication of "Lessons on Electrochemical Corrosion".

Since the beginning of 1955 the Association has issued a number of memoranda on the electro-chemical behaviour of the following metals: nickel (technical Report RT.23), tin (RT. 25), germanium (RT.27), vanadium (RT.29), uranium (RT.31), tungsten (RT.32), and tellurium (RT.33). A standard table of free enthalpies of formation has been compiled and published (RT.28), as well as the second part of a course of lectures given by Mons. M. Pourbaix at Brussels University. This deals principally with chemical equilibrium in aqueous solutions.

Technical Activities

The technical activities of CEBELCOR are carried out either through the medium of technical committees accessible to all members, or within

A Note on its Constitution and Activities

the framework of private consultation, or in the form of continuous technical service accorded to certain members.

Two such Technical Commissions (CT) are at present developing research programmes with the help of the I.R.S.I.A.

CT4.—*Cathodic Protection*, under the chairmanship of Mons. R. de Brouwer, technical director of the Société Distrigaz; the cathodic protection of structures in steel, lead and lead alloys; zinc and magnesium reactive anodes.

CT12.—*Descaling Methods*, under the chairmanship of Mons. M. de Grave, Inspector General of the Ministry of Public Works; physical methods of combating scale incrustation by water and aqueous solutions (principally, the electrical and magnetic methods).

Direct technical aid, given to members of the association, has principally been under one of the following five heads:

- (a) Verbal advice, given at the offices of CEBELCOR;
- (b) Visits to members' works, by the Director or one of the research workers of CEBELCOR, or by the personnel of one of its members, for instance, the "Corrosion Service" of the Belgian Industrial Association;
- (c) Brief, experimental researches, made in the laboratory or at the plant itself;
- (d) In some cases of particular importance, long-term, theoretical research. In such cases a thorough experimental investigation is made in close collaboration with the member concerned, usually in two stages:
 1. A competent engineer or chemist from the personnel of the member in question spends some time in the CEBELCOR laboratories. The association is thus made fully conversant with the problem pre-occupying the particular member, who at the same time is acquainted with the research methods of the association, and an experimental programme is set up;
 2. The particular research worker then returns to his works and there conducts a research programme in close contact with the association.
- (e) The association has been asked to collaborate in establishing an anti-corrosion service for a particular plant, a type of service which is already largely justified and profitable, in

very many industrial undertakings, particularly in large chemical and petroleum plants.

The number of such consultations given by the association up to the present time exceeds 150, and in 1955 the following subjects were dealt with:

Building Industry and Public Works.—The passivation of steel in the presence of cement. The behaviour of expanded concrete as a heat insulator; the corrosion of ferro-concrete reinforcing metal. The corrosion of concrete-sheathed, electrical conduits. Plastic joints for conduits. The protection of water pipes. The protection of high-pressure conduits for hydro-electric power stations. Corrosion of copper pipes. Water treatment plants for various purposes.

Electrical Industry.—The corrosion of circuit breakers.

Chemical and Foodstuffs Industry.—The corrosion of ammonia condensing refrigerators. Heat insulating materials for steel and aluminium tanks. Corrosion in sulphuric acid plants. Corrosion of water heating coils. Zinc corrosion in the presence of detergents.

Metal Working Industries.—Corrosion and incrustation (scaling) in steel wire drawing. Corrosion in the motor industry. Boiler tube corrosion.

Electrochemical Industries.—Zinc corrosion in manganese dioxide batteries.

Shipbuilding Industry.—The corrosion of ships' hulls.

Petroleum Industry.—The general protection of refinery plant.

Various Industries.—The protection of metals against corrosion by surface treatment with phosphoric compounds.

On the other hand, the association has given aid to the "Corrosion Service" of the Belgian Industrial Association in particular cases of corrosion affecting a number of Belgian industries; under the auspices of this "Corrosion Service", M. Laureys, an engineer of CEBELCOR, spent several months in the Belgian Congo, during which he supervised the organization of protective painting for the high pressure conduits of the Zongo Power Station.

Courses, Conferences and Meetings

In addition to the course of lectures on electrochemical corrosion given by Mons. Pourbaix at Brussels University already referred to, several conferences have been held since the beginning of 1955 under the auspices of the association, in particular on the occasion of the "Journées d'Etude du Cebelcor" at Brussels on April 13 and 14, 1955; within the framework of which, among others, Dr. F. L. Laque, Vice President and Director of the Development and Research Division of the International Nickel Company of New York, read a paper, followed by a discussion, under the title of

"Corrosion Research". Since the beginning of 1956 three conferences have been organized.

The first, in collaboration with the Royal Belgian Society of Engineers and Industrialists, at which was presented a paper by Mr. J. F. H. van Eijnsbergen on "The Protection of Steel by Metallic Coatings"—in particular by Hot Galvanizing" (followed by a showing of the film "Must it Rust" of the American Hot-Dip Galvanizers' Association).

The next, jointly with the Royal Belgian Society of Engineers and Industrialists, and the Belgian Federation of Structural Engineering Contractors (FABRIMETAL), received a paper by H. C. Castell (Mond Nickel Company, London) on "Nickelplating and its Industrial Applications".

At the third meeting on June 12, a paper was read by Dr. Partridge, director of Hall Laboratories, Pittsburgh, Pa., on "The Treatment of Boiler Feed and Freezer Water with Special Reference to the Use of Metaphosphates".

Members of the association have also taken part in a number of scientific congresses in Belgium—and other countries; among which may be particularly mentioned the 7th Reunion of the International Committee on Thermodynamics and Kinetic Electrochemistry (CITCE), held at Lindau in Germany in August, 1955, during which CEBELCOR research workers presented ten communications of a scientific and administrative character, which will probably be published in the transactions of the 7th Reunion.

The association, which provides the General Secretariat of CITCE, is at present preparing, in collaboration with Prof. A. Rius, National Secretary for Spain of CITCE, for the 8th Reunion of the Committee, which will be held at Madrid, between September 17 and 23, 1956.

Documentation

A documentation service regularly reviews about 70 periodicals and a considerable number of summaries and memoranda. Bibliographical references are assembled in a card-index which, together with the documentation service on Corrosion of the National Association of Corrosion Engineers (NACE) is at the disposal of members.

The "Bibliography" section of the association's "Information Notes", giving a quarterly selection of abstracts from the principal recent publications on corrosion, and a loan service for documents and journals, complete the documentation facilities provided by CEBELCOR.

Publications

The publications of the association can be broadly divided into three principal groups.

1. Memoranda and papers of general interest describing the organization and its work in the field of corrosion prevention.

(Continued in page 284)

The Deposition of Nickel: Discussion

(continued from page 281)

minium they were achieving 3.75 per cent. elongation before failure.

Heat treatment could improve the ductility of the coating, but it meant using a high temperature (700° C.), which was not always practicable with certain materials.

The four drawbacks of the Brenner and Riddell solution listed in the paper had to be taken together. Certain of the points might not apply, but if the four were taken together they were disadvantages which Mr. Aitken felt could be overcome. They had now plated a complete range of aluminium alloys without any difficulty whatever, including the high-silicon die-casting alloys with as much as 13 per cent. silicon. There was a slight roughening of the surface on these high-silicon alloys due to the etching procedure. No difficulty had been experienced in plating two-phase alloys, and even leaded two-phase alloys, provided the lead content was not too high. Difficulty arose, however, when stripping, particularly when stripping two-phase alloys.

It was true that the phosphorus content of the plate tended to make more brittle welds. In that connection, Kanigen metal could be used as a fluxless brazing material. This aspect was being developed in this country and in America, and very good welds had been obtained by using solid alloy. The question of diffusion had been raised, but there was no evidence of diffusion of the phosphorus content of the nickel-phosphorus until the melting point of the nickel-phosphorus alloy was reached, and then some diffusion would take place.

All the various solutions mentioned by Mr. Bunce would work. Mr. Aitken said that his company had chosen the particular solution which they used because it represented the best commercial compromise between the price of the constituent chemicals and their efficiency. The use of chloride had been abandoned because the sulphate available in this country was purer. The chloride was apt to have heavy metals present, which affected the quality of the plate.

The question of the tank material was an interesting one. The choice of the material depended on whether or not it was desired to operate for 24 hours a day and on the method of heating used. He recommended external indirect heat exchangers, some installations used flash evaporation and direct steam injection; these methods were not considered to be satisfactory because of the temperature gradient across the bath. Other users installed immersion heaters in a static tank. The type of heating must influence the decision on the tank materials to use. Glass fibre tanks had been used, and he was trying some out now, but some nervousness was felt about shock fracture. This would

probably not apply in Mr. Bunce's case, but Mr. Aitken was considering the plating of articles weighing up to 5 tons, and did not want them to crash through the bottom.

With regard to corrosion resistance, his company was now developing a technique whereby it was possible to get complete corrosion resistance when submerged in seawater, and in fact a new sulphur-producing plant in the Gulf of Florida was having all its underwater pipes—some 40 miles of them—plated by this method, to give complete resistance.

The method was to plate perhaps 0.001 in. remove the component from the plating solution, reactivate the Kanigen surface and then plate another 0.001 in. The resistance of Kanigen could not be expected to be any better with sulphur than that of pure nickel; after all, it was 92 per cent. nickel.

The most telling test was the new autoradiographic technique used in America. Radio-active iron was plated on to the steel components and allowed to decay to a given activity level.

These components were plated with Kanigen and other nickel deposits and the porosity of the plates were then measured by exposure to an X-ray film. The results obtained showed that the chemical plating, which was in fact Kanigen, was the best, followed by a nickel-phosphorus alloy produced by an electrolytic phosphorus acid solution, then a bright nickel solution and then the ordinary Watts nickel solution, in that order.

He could only agree with Mr. Silman about the physical properties of the coating under stressed conditions; flexing would cause microscopic cracks. Whether they were better or worse than the pores obtained in electrodeposited nickel he would not like to say.

Belgian Corrosion Research Centre

(Continued from page 283)

2. Original scientific papers published in the form of technical reports, several of which have been referred to earlier in this article. Such papers have also appeared in the Transactions of CITCE meetings and in various technical journals and reviews.

3. Information notes which are published quarterly and which contain, as well as reports on the activities of the association and the bibliographical section already mentioned, general information on the activities of organizations concerned with corrosion problems, and notes on corrosion.

In the light of its reception by official bodies and industrial organizations the Belgian Corrosion Research Centre is satisfied that the campaign against corrosion at all technical and scientific levels is winning for itself acknowledgment as an important part of our present-day economic scene.

A Comparative Survey of STOVING

by

CONVECTION and RADIATION

by LEO WALTER, A.M.I.Mech.E., M.Inst.F.

(Continued from page 34, January, 1956)

STOVING BY CONVECTION

LOOKING back into the past it seems that the great physicist Sir Isaac Newton in 1701 was one of the first scientists to draw attention to the law of cooling. He related the rate of temperature drop of a body exposed to a steady air current to the temperature differential between the material to be cooled and the cooling medium. The same law applies to heating by means of hot air. In 1787 Sir Benjamin Thomson deduced for the first time the air-layer or air-film theory. He discovered that resistance to heat transfer during convection resulted from an adherent, nearly stagnant layer of air on the surface of a solid body. The "heating-up" period of a convection stove can, therefore, be considerably shortened by using forced circulation of hot air. This modern method not only dissipates stagnant surface films of moderately warm air on articles during stoving, but also brings continuously fresh hot air into close contact with the surface to be stoved. Experimental work carried out in research organizations and in test laboratories of stove manufacturers and paint makers during the last 30 years, in order to investigate the factors influencing hot-air stoving and drying has been considerable, so allowing designers to deviate from purely empirical designs; today the accumulated experience and data collected over many years allow the calculation of most design factors with unfailing certainty. In addition, operational experience in drying by convection in other branches of industry has contributed to achievements in paint stoving.

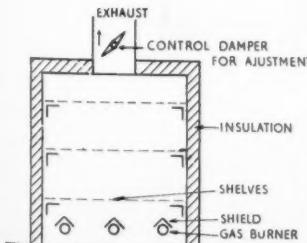


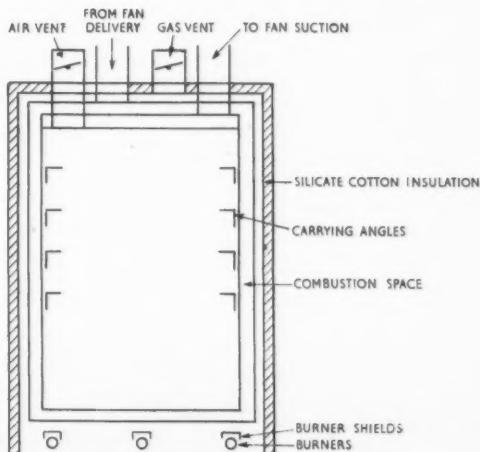
Fig. 1 (left).—
Double - cased
stove, direct gas-
fired, with natural
convection (no fan
in use).

Fig. 1A (right).—
Principle of forced
convection stove
with fan.

[Courtesy of A. E.
Griffiths (Smeethwick)
Ltd.]

Briefly, the development of paint drying methods proceeded as follows. Simple air drying (*i.e.*, with no heating at all) is a very time-consuming method and in the case of paints drying solely by evaporation of solvent, the air drying time can be about 30 minutes, but for paints drying by oxidation it may be up to 24 hours. This latter method is rarely used today in industrial drying, but is still widely adopted for paints used *in situ*, or for steel constructions for buildings, bridges, chemical plants in the open air, etc.

For relatively small articles "force-drying" was later applied, temperatures of about 150° F being used in very simple ovens. For paints that require polymerization considerably higher temperatures of from 200° to 500° F were required, and more elaborate oven types were designed. Stoving time could thus be reduced—assuming that the nature of the goods lent themselves to quicker methods—in more up-to-date stoves. The box-type oven (Fig. 1) with direct firing and natural convection, or (Fig. 1A) with indirect firing, was for a long time a fairly efficient means of batch drying. Temperature was hand controlled and various improvements were



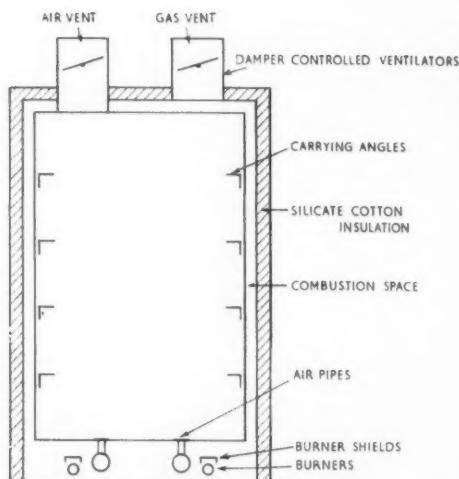
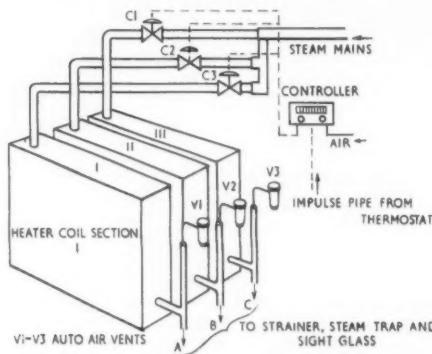


Fig. 1B (above).—Treble-cased oven with indirect firing and natural convection.

[Courtesy of A. E. Griffiths (Smethwick) Ltd.]

Fig. 3 (below).—Improvement of air heater battery by sectionalized control of coils.

NOTE.—Splitting-up of a large battery and using steam traps and air vents for each section improves heating. Automatic control in sequence of the sections improves accuracy of temperature control.



gradually introduced in the designs. For some processes where the required drying rate is low and output is moderate, the modern box ovens are still in use and can work efficiently. Heating media can be town gas, fuel oil, electricity, steam, or hot water. For electrically-heated ovens tubular-sheathed heating elements are readily adaptable; they can be disposed along the bottom or sides, or standard elements can be fitted inside the oven, a flexible method. (Fig. 1B.)

Fan circulation of hot air during stoving speeded up the process, and as the quality and variety of coating materials and stoving finishes progressed the design of forced convection ovens developed rapidly. Today's ovens with vigorous air movement are suitable for both batch and continuous operation

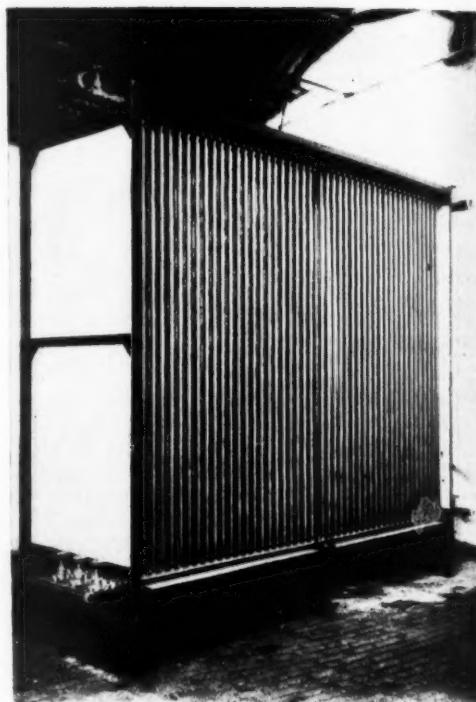


Fig. 2.—Weldex heating element.

[Courtesy of Wellington Tube Works Ltd.]

for a variety of uses. The air may be heated by gas or oil burners in a separate combustion section and is circulated by an induction fan. Alternatively, for lower air temperatures a steam-heated air heater battery can be used with a fan (Fig. 2) for driving the incoming fresh air over hot finned tubes. For certain operations a pre-heating zone can be applied to heat up the article to the stoving temperature. In continuous travelling or tunnel ovens the work is passed through on a conveyor. Hot-air circulation and re-circulation of part of the exhaust air is used for achieving maximum possible thermal efficiency in modern designs. Conditions of rapid air flow must, of course, be met by the use of paints suitably resistant to abrasion if dust and grit are present in the air stream. Timely withdrawal of work is sometimes essential where maximum stoving temperature and minimum of time might produce breakdown or discolouring of the paint when working near the critical conditions. Rapid convection stoving has thus its limitations, arising from the quality of the coating material (in addition to other factors such as cooling time, etc.).

Where oven temperatures are required which are higher than obtainable from saturated steam and where the cost of electric current allows, electrical elements afford a simple alternative or

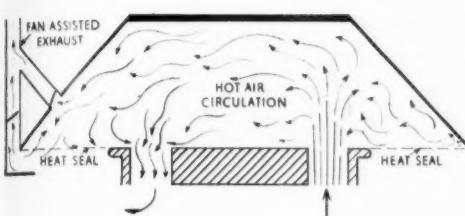


Fig. 4.—Air circulation of camel-back drying tunnel.

dryer electric heat can be applied (a) in a separate heater mounted outside the dryer, or (b) by placing elements inside the oven in such a way as to heat the main circulating air stream. An electrical air heater may have elements of hairpin shape located in several staggered rows transversely to the air-flow. Sheath temperatures up to about 1,382° F can be reached with suitable elements, which are available from reputable makers.

In contrast to electric heaters, a steam-heating installation has to be so designed that the overall heat transfer coefficient from the heating coils is high enough. Gilled or finned pipes enable the steam to give up its latent heat during the formation of condensate and correct steam trapping and air venting (Fig. 3) is essential to prevent water-logging and air-locking which would hamper heat transfer and prolong heating-up time from cold. The latter is regarded as a decided disadvantage of convection stoves as compared with radiant-heat ovens. For older existing plants improvements in heat transfer can, however, considerably improve the time for heating-up from cold.

Efficiency

When computing the thermal and overall efficiency of a drying oven, in general, the following sources of heat have to be considered when comparing heat input to useful heat:

- (1) Heat required for raising temperature of the coating to point of vaporization of moisture or of solvent.
- (2) Heat required to evaporate the moisture or solvent, *i.e.*, to transform from liquid into gaseous state.
- (3) Heat needed for heating-up the air entering the oven or dryer to replace heat expelled with exhaust air or gases. (Re-circulation reduces the amount).
- (4) Heat required to elevate the temperature of the oven structure, trucks, trays, or of the conveyor mechanism which may continuously pass through. (Insulation of stove reduces demand.)

It is clear that forced convection stoving, *i.e.*,

using hot air as the heat carrier and circulating it by means of fans around the articles, will produce rapid stoving and may reduce cost. There is, however, a critical stoving temperature which must not be exceeded, and this can be achieved by applying precise thermostatic control. There is also a definite air speed and air volume which should be aimed at. On the other hand to exceed it would not help, because the rate of drying can only be increased to a certain extent. The criterion that optimum air flow conditions have been attained is the saturation of the exhaust air leaving a drying oven. By measuring the relative air humidity in the exhaust duct (at maximum permissible outlet air temperature) it can be made sure that the correct air volume is used. As is well-known, the more humid the outlet air is, the better is the actual absorption of moisture for a given air volume. With a camel-back oven, an adaptation of the ordinary tunnel oven using a conveyor, it is most important to have a fan speed which provides efficient heat seals at both the oven inlet and outlet openings. The basic principle of this widely used type of stove is that the circulated hot air disperses through the length of the oven. As hot air always rises, very little will be lost at the two openings, provided hot-air extraction is adequate. (Fig. 4). Correct stove operation has to ensure that the exhaust fan and outlet air damper are operated so that a balanced air flow takes place, *i.e.*, that the hot-air volume introduced by the main circulating fan finds its way out easily from the stove, without effecting the air seals. The air pressure conditions inside the stove will then be such as to avoid spilling out of hot air. In modern finishing plants, by coupling a humped-backed drying tunnel to an automatic continuous dipping system the coating and stoving process becomes automatic. Where the quality of the coating requires air-drying before stoving to evaporate the more volatile components, or where air pre-drying is required as a safety measure against fire, automatic operation becomes more difficult, or even impossible. The target of "automation" may, therefore, be farther off than is often realized, for a metal-finishing plant.

Safety

At the time of writing this survey, the findings of the Gas Council undertaken at the request of the Factory Inspectorate into ways of preventing the damage and injuries caused by explosions in box-type drying ovens, have just been published. The memorandum recommends the use of explosion "reliefs" with a vent area of 1 square foot for every 15 cubic feet of oven volume. The relief recommended is to replace the top of the box oven by an open wire mesh, covered by a sheet of aluminium foil to produce a seal, resting on an angle support.



Fig. 5A (above).—Large Sturdy batch-type stove.

[Courtesy of Sturdy Engineering Ltd.]



Fig. 5B (left).—Sturdy camel-back stove for castings.

[Courtesy of Sturdy Engineering Ltd.]



Fig. 5C (above).—Sturdy stove heated by high-temperature hot water with forced circulation.

[Courtesy of Sturdy Engineering Ltd.]

An insulating panel of mineral wool weighing 0.9 lb. per square foot rests on top of the metal sheet. In an explosion the relief cover flies into the air. In the light of these experiments, the memorandum of the Factory Department of the Ministry of Labour on "Safety in design and operation of gas-heated ovens and furnaces" will be amended. It is hoped that the 30,000 stoves in use in this country, mainly for japanning, enamelling or paint drying of smaller articles, will lend themselves to reconstruction for incorporation of "safety reliefs". Users who are interested should read a shortened version of the report published by the Gas Council's Midland Research Station, Solihull, near Birmingham, which is available upon request.

Convection Stoving Plants in Operation

In the following, a few stoving plants will be briefly described and illustrated. Data and illustrations have been supplied by several leading makers of convection stoves as mentioned in each "case

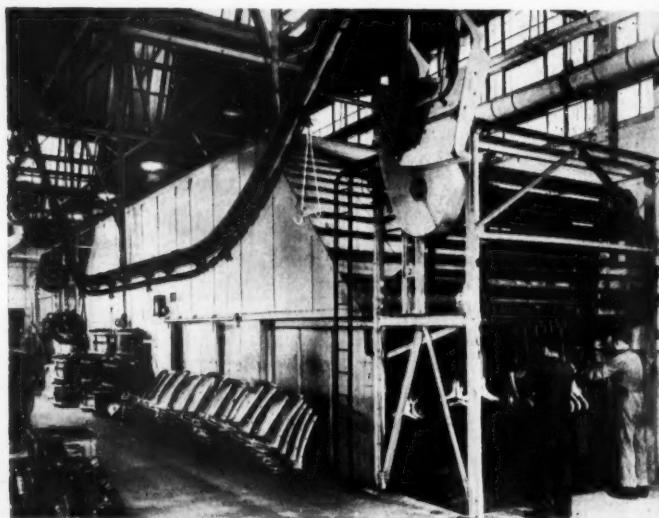


Fig. 5B (left).—Sturdy camel-back stove for castings.

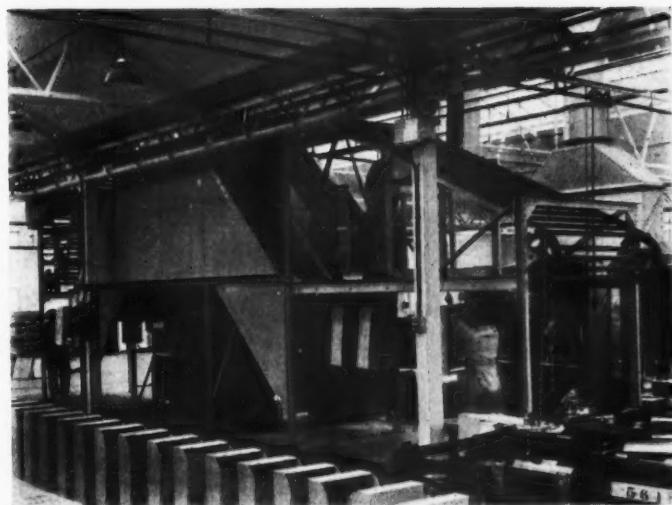
[Courtesy of Sturdy Engineering Ltd.]

Fig. 5C (above).—Sturdy stove heated by high-temperature hot water with forced circulation.

[Courtesy of Sturdy Engineering Ltd.]

Fig. 5d.—Stove for stove enameling synthetic enamels to sheet metal components.

[Courtesy of Stordy Engineering Ltd.]



history", and the author is indebted to the firms for their assistance. The examples have been selected at random to give a broad view of various plant types in use.

The large batch-type stove made by Stordy Engineering Ltd. of Wolverhampton, as illustrated in Fig. 5A, has a clear loading size of 12 ft. cube, and while originally designed and constructed for producer-gas firing, is now fired by town gas. The stove has a working temperature range up to 350° F. It is used for stoving both prime and finish coats on steel windows and sheet-metal partitioning. Normal types of paint in use are of the synthetic variety.

Fig. 5B shows a Stordy large forced-air circulated plant in operation. This camel-back type stoving oven was installed for the stoving of synthetic prime and finish coats on castings weighing from a few pounds up to a maximum of 5 cwt., but it takes also sheet-metal work. The stove under production conditions, for synthetic paints, runs at a controlled temperature of 300° F, although it has been designed for a maximum temperature of 400° F. The stoving time in the apex is 30 minutes, but varies with the articles. The clear hanging depth through the system is 5 ft. with an effective loading width on the crossbar of 10 ft.

The Stordy camel-back stove shown in Fig. 5C, is heated by high-temperature hot water, and is of forced-air circulated design. It is installed in the Coventry factory of a well-known manufacturer, and is in use for prime and finish dip coats on a multiplicity of components. The latter include car wheels, petrol tanks, etc., and the effective stoving time in the apex is about 45 minutes at a working temperature of 250° F. Sprayed work is also stoved in this oven, which has an effective

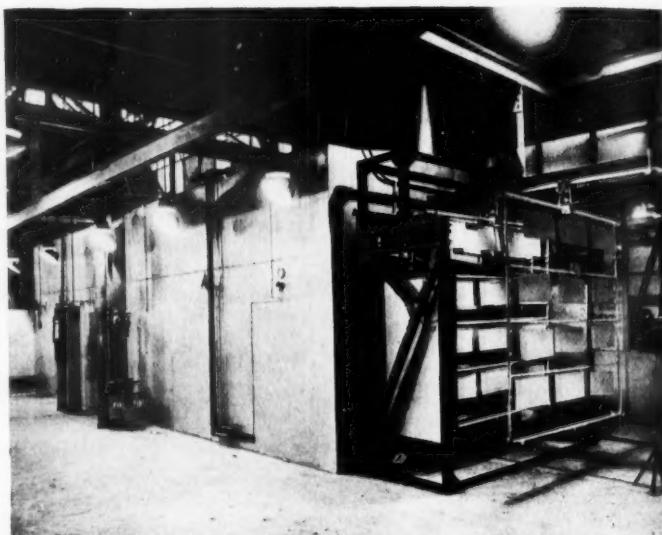
crossbar width of 8 ft. and a clear hanging depth of 5 ft. 9 in.

An interesting smaller stoving plant (also of Stordy manufacture) is shown in Fig. 5D; it is used for stove enameling synthetic enamels on sheet-metal components. The effective stoving time in the apex is only 10 minutes (using forced-air circulation) at 320° F, although the stove has been designed for a maximum working temperature of 400° F. The crossbar loading width is 4 ft. 9 in., the clear hanging depth through the system being 3 ft. These plants clearly demonstrate what can be achieved with a well-designed forced-air circulation system.

Large-volume low-pressure hot-air circulating ovens for drying and enameling processes using various heating media, are manufactured by J. L. S. Engineering Co. Ltd., of Kings Norton, Birmingham 30. The temperature ranges are as follows: gas (town or producer) from 100 to 1,500° F; electricity: 200-250-volt, 1 phase, 400-440-volt, 3 phase from 100 to 1,500° F; steam up to 100 lb. per sq. in. from 100 to 270° F; and hot water from 70 to 180° F. The makers claim that air-circulating heat treatment plants of J.L.S. design are in operation for drying of radiators, refrigerator parts, etc., and for stove enameling of car and cycle parts, etc. The makers also claim that they achieve absolute temperature uniformity throughout the working space of their stoves, an important feature, for drying and baking of coated metal and other goods. Fig. 6A illustrates as an example, a J.L.S. conveyorized oven with gas firing for enamel paint drying. The oven dimensions are 30 ft. long, 10 ft. wide and 10 ft. high working space. The capacity is 5 tons of prefabricated parts per hour at 300° F. Equipment includes

Fig. 6A.—Conveyerized oven.

[Courtesy of Austin Motor Co. Ltd. and J. L. S. Engineering Co. Ltd.]



motor, circulated-air fan, gas burner box and burner rail, and instrumentation including indicators and automatic controllers. There are several heated zones in the oven, each zone having independent air circulation and a gas-fired heat exchanger with temperature control. In this instance the products of combustion do not come into contact with the articles, but where permissible the combustion gases can be utilized in the working space, thus increasing fuel economy. From the instrumentation used, it appears that special care has been taken in the oven design to produce closely automatically controlled temperature in each oven zone.

Another example of a J.L.S. gas-fired air cir-

culating oven is illustrated in Fig. 6B. This is a batch-type oven using trolleys on castors for wheeling cycle frames and other cycle components into the stove for finishing. The hot-air circulation is provided by fans mounted in the oven roof. No combustion products come into contact with the articles, a heat exchanger being used. This and very close thermostatic control of air temperature allows a full range of different coloured enamels to be treated at the same time. The design can be adapted to floor or overhead runways for introducing the load into or through the oven. An important feature is that the temperatures of the solvents' drying sections and the enamelling area are balanced to suit working conditions, by simply

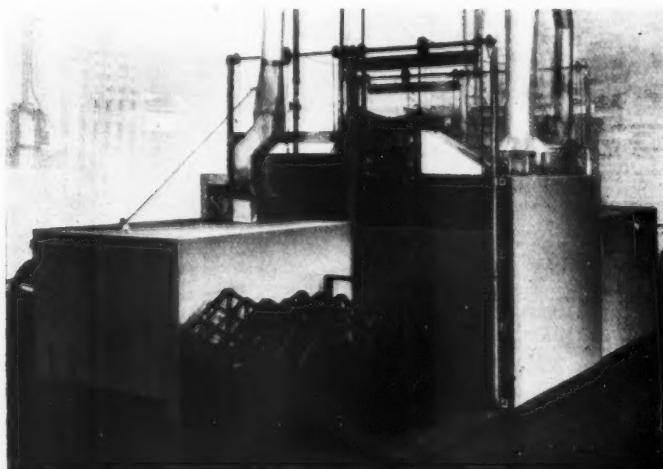


Fig. 6B.—J.L.S. enamelling stove for cycle parts.

[Courtesy of Associated Cycle M/C of Coventry Ltd. and J.L.S. Engineering Co. Ltd.]

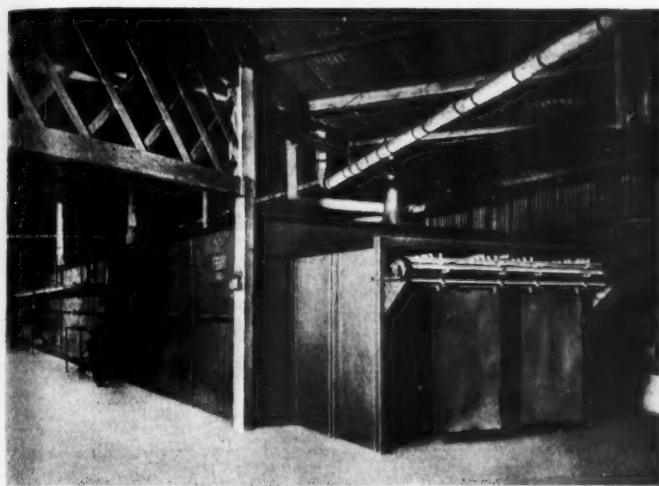


Fig. 7A (left).—Zoned tunnel stove.

[Courtesy of L. A. Mitchell Ltd.]

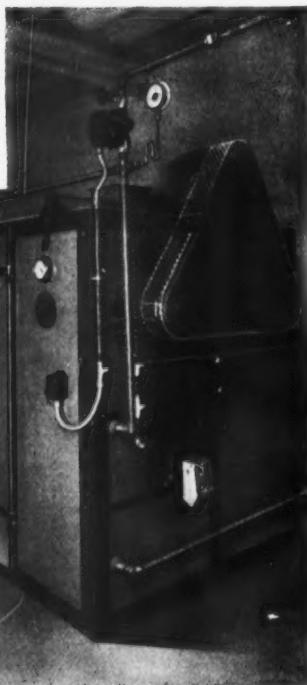


Fig. 7B (above).—Mitchell stove for rapid drying.

[Courtesy of L. A. Mitchell Ltd.]



re-setting of the controlling thermostat. It is claimed that a typical stoving time for enamelled cycle frames is about 20 minutes.

A firm specializing for many years in modern industrial drying equipment for the process industries is L. A. Mitchell Ltd., of Manchester.

Fig. 8A (below).—"U" shaped tunnel oven for stoving sheet metal components or machinery parts.

[Courtesy of Heat and Air Systems Ltd.]

As an example from the very wide range of hot-air drying stoves manufactured, Fig. 7A shows a zoned large tunnel stove for continuous suspension conveyor drying of large sheets of materials, such as coated paper-boards, leather and similar materials. The material is suspended on suitable clips on the conveyor and is conveyed through a drying tunnel composed of a number of zones, the drying conditions in which can be closely controlled as regards temperature and humidity. These Mitchell stoves are generally arranged for steam heating, although gas or electricity can be used where desirable. Fig. 7B shows a smaller batch-type



Fig. 8B (left).—Drying oven for painted drums and containers.

[Courtesy of Heat and Air Systems Ltd.

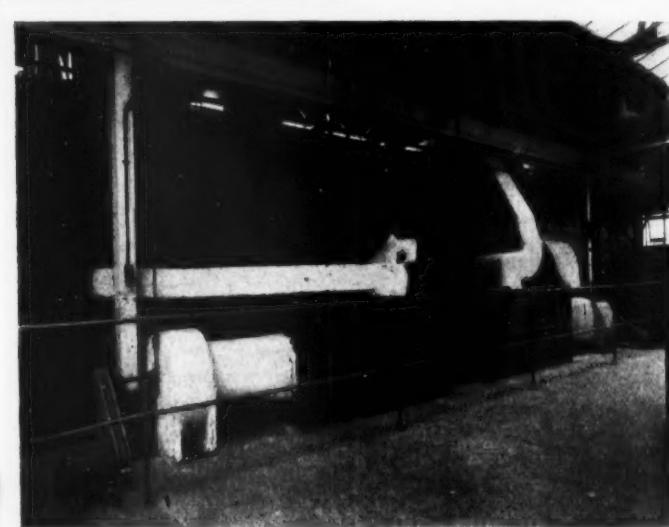


Fig. 8C (right).—Oil-fired heaters for drying and baking oven.

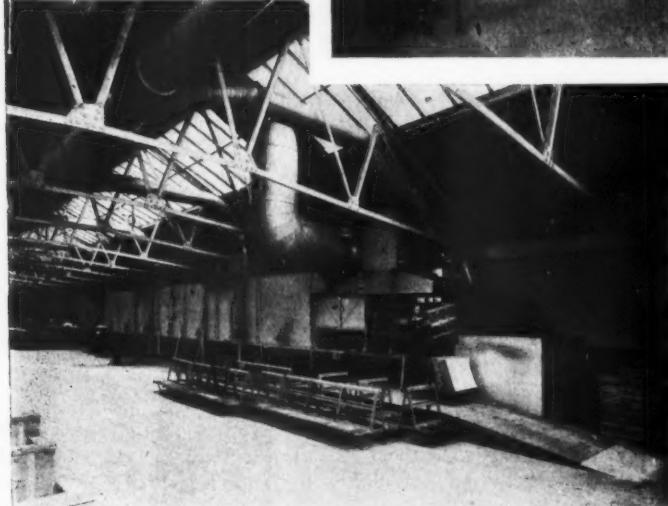
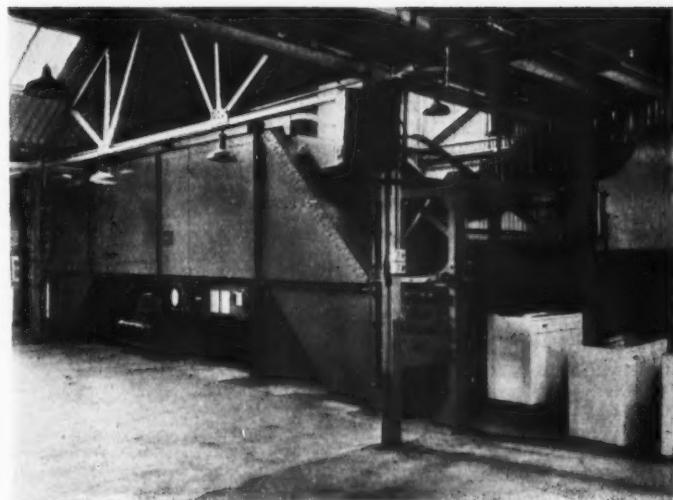


Fig. 9 (left).—Continuous tinplate dryer.

[Courtesy of Davidson and Co. Ltd.

Fig. 10A.—Conveyor oven for stoving kitchen sink units.

(Courtesy of A. E. Griffiths (Smethwick) Ltd.)



Mitchell stove used for the drying or casing of a variety of products, such as coated paper tubes, etc. The articles are supported on trays within the stove and exposed to a hot-air stream produced by circulating fans. Suitable heaters are incorporated into the design. The photograph shows a steam-heated stove, but electrical or gas-fired types are also available. The makers claim that the system of air circulation employed, together with insulation of the stove housing results in very uniform and efficient heat treatment.

A "U"-shaped tunnel oven designed and manufactured by Heat and Air Systems Ltd., of London, S.W.1, is illustrated in Fig. 8A. This design can be applied to various stoving operations, and is

shown for stoving sheet-metal portions of flour milling machinery. The requisite conditions, *i.e.*, baking the enamel at 250° F, have been obtained by means of an externally mounted direct gas-fired air heater, discharging products of combustion mixed with requisite fresh air through high-velocity nozzles fitted at high level in the tunnel. These nozzles, which can be seen on the right-hand side upper part create the necessary turbulence of hot-air movement, the re-circulated air being drawn up and back to the heater *via* the openings indicated on the left-hand side. The ends of this oven are provided with special vestibule-pattern air blow-heat seals, and the articles pass through the oven hung on over-head conveyor trolleys.

Fig. 8B illustrates a "HAS" drying oven for painted drums and containers (pails). The design is a "double-deck" type drying and baking oven,



Fig. 10B.—Conveyor oven, direct gas fired.

(Courtesy of A. E. Griffiths (Smethwick) Ltd.)

Fig. 10c.—Large direct-gas fired conveyor oven for stoving of motorcycle components.

[Courtesy of A. E. Griffiths (Smeathwick) Ltd.]

the drying section being on a slat conveyor passing through the lower section, and the paint backing being carried out through the upper section. The work is carried through the stove suspended on a Teleflex-type cable conveyor, which also travels the work previously through a spray booth. The drums are dried in the lower section after a water test.

Fig. 8c shows the oil-fired air heaters for the upper and lower decks respectively. The oil-burner equipment is of the pressure-jet type, and has gas ignition to obviate any risk of fuming when starting from cold. The fuel oil used in this instance is of medium-grade distillate quality. A full set of thermostatic controls and flame-failure equipment is provided for each heater. In the illustration, the oil-fired air heater on the left serves the lower deck (drying) section of the stove, and the heater shown on the right serves the upper deck (baking) section.

A tinplate drying oven of modern continuous construction is illustrated in Fig. 9, as made by Davidson and Co. Ltd., Siroccoworks, Belfast, for the tinprinting industry. In tinprinting

operations the drying process requires very efficient air circulation and close temperature control with carefully regulated drying zones. The great number of these "Sirocco" ovens in practical use confirms the soundness of the design principles on which this continuous-type oven has been developed.

The number of batch-type ovens in operation in smaller works is very great in this country. Double-cased ovens with direct-fired natural convection, treble-cased stoves with indirect-fired natural convection, and batch types with forced convection can be found in use in the metal and other industries using gas burners. For stove enamelling, electrically heated box ovens are also in use, and either trolley

or tray-type loading can be applied. Many of the above stoves had been manufactured by A. E. Griffiths (Smeathwick) Ltd., of Handsworth, Birmingham 21. The company also manufacture continuous conveyor ovens. Fig. 10a illustrates a Griffiths conveyor oven, direct gas-fired, for stoving generally white or cream undercoat on kitchen sink units. The instrument and control panel can be seen in the centre. The undercoat is sprayed on to the partly assembled unit and is stoved for 15

(Continued in page 298)

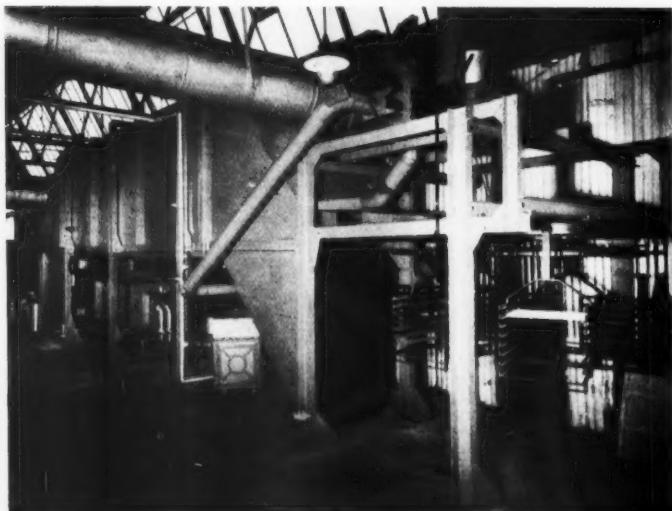
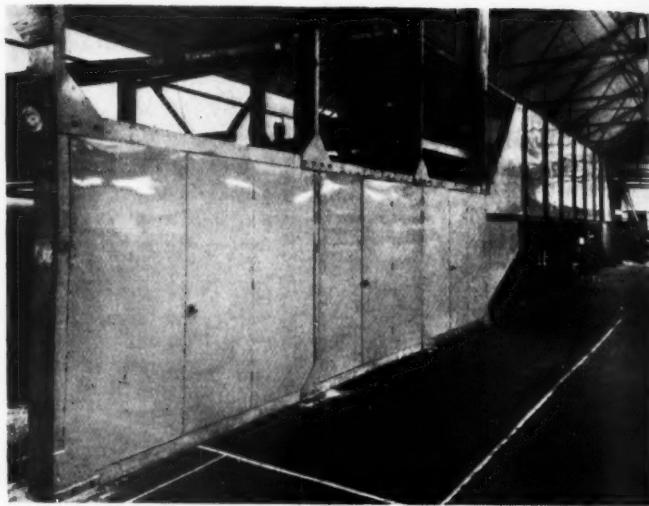


Fig. 10d.—Griffiths conveyor oven incorporating a monorail with fixed carriages for enamelling small presswork on trays.

[Courtesy of A. E. Griffiths (Smeathwick) Ltd.]



Some Notes on BI-POLARITY of NICKEL HEATING COILS

by D. W. TAYLOR, Grad.I.E.E.

WHEN it is required to heat large volumes of nickel-plating solution to its desired operating temperature, the most economical heating medium is steam or high-pressure hot water. Owing to the chemical nature of this solution it is only generally possible to transfer the heat in three different ways. These are:—

- (1) A coil of pure nickel tube, through which the steam passes, immersed in the nickel solution.
- (2) A coil of pure nickel tube covered with a suitable insulating material, again immersed in the nickel solution.
- (3) A heat exchanger, external to the plating vat, made from a suitable material, *i.e.*, inert to the chemical action of the nickel solution.

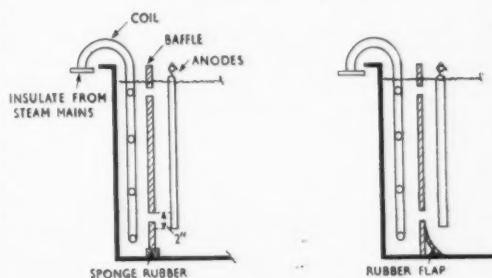
A method commonly in use in this country is a coil of pure nickel tube immersed in the solution. In large vats it is necessary to install two or more coils, both to obtain the necessary heat transfer and, by careful positioning, to obtain good heat circulation so as to avoid excessive temperature gradients. These coils are normally located in blister tanks, which are attached and open to the main vat; alternatively they are immersed directly into the main vat and close to its walls and behind the anode bars, which support the anodes hanging in the solution. In order to assist thermo-syphonic circulation of the local solution, and thus obtain a relatively even distribution of heat throughout the vat, it is usual to place baffles in front of these coils, these baffles having a row of holes or slots cut in them in suitable positions. Under these particular conditions it is sometimes possible for a circulating current to flow between the anodes and one point or section of the heating coil and from another part of the coil to the cathode *via* the work being plated in the vat. In this case, the section of the heating coil into which the current can be taken as entering from the anodes, will assume a relative cathodic potential while at the other section of the coil, where current may be taken as leaving the heating coil for the cathode, it will assume a relative anodic potential. This condition is known as bi-polarity.

The heating coil, because it is of pure nickel,

will act at these points, as a normal anode or cathode in a nickel plating vat, that is, the section of heating coil at which the current is entering, being of a relative cathodic potential to the anodes, will receive a deposit of nickel. Similarly, the section of the heating coil from which the current is leaving, being of a relative anodic potential to the cathode, will disintegrate or as it is commonly called, "plate-off". The rate of build-up at the one section and plating-off at the other, depends upon the value of the circulating current flowing in this secondary circuit in the vat. The danger with this condition lies at the latter section, where, due to plating off, the wall of the nickel tube forming the heating coil will weaken, and eventually burst, which in turn will result in contamination of the solution or its total or partial loss. The latter case is the most usual result, due to the solution being syphoned into the steam system and either passing down the drain by way of the condensate line, or in a closed system, being fed back into the boilers. In order to avoid these disastrous circumstances, the following conditions should be fulfilled.

To eliminate any stray currents flowing into the coil from the tank sides, or from the steam mains feeding the heating coil, the coil must be electrically insulated where it makes mechanical contact with the tank or the steam mains. The coil must also be efficiently baffled, not only, as previously mentioned, to allow good thermo-syphonic circulation, but also to eliminate, as far as possible, stray

Fig. 1.—Cross section of tank.



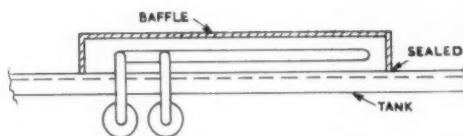


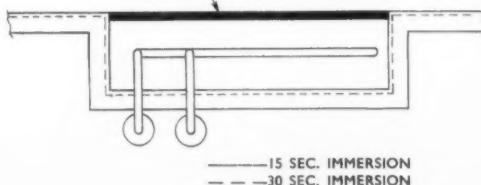
Fig. 2.—Plan of coil in tank.

currents. A baffle to be efficient in both respects should be designed along the following lines:

It can be fabricated either from Perspex or of rubber-covered mild steel and it should extend from the solution level down to the bottom of the tank, where it should be sealed against the flow of solution and the flow of circulating currents. If the baffle is manufactured from Perspex, this sealing may be achieved by allowing it to rest on a strip of sponge rubber, or if it is manufactured from rubber-covered mild steel, it may be achieved by fitting a soft rubber strip (see Fig. 1). Whichever method is used, it is necessary to ensure that there is a complete seal between the baffle and the bottom of the tank. The baffle should also fit around the sides of the heating coil to the tank walls (see Fig. 2). Where the baffle meets the tank walls it should again be sealed with either sponge rubber or a soft rubber flap, as previously mentioned. The heating coil is now completely enclosed by the tank walls, the tank bottom and the baffle. In the case of a blister tank containing the heating coil, the baffle fits across the opening of the main vat, again being sealed with sponge rubber or soft rubber flaps (see Fig. 3). When the coil is completely enclosed in this manner, circulating currents cannot pass between the anodes, the coil and the cathode, but neither can solution flow from the heating compartment thus formed to the main body of the nickel solution in the vat. Therefore, the baffle must have holes cut in it to allow thermo-syphonic circulation to take place, but they must be carefully positioned to minimize the effect of the polarizing currents. These holes should not be more than 2 in. diameter and the row at the bottom of the baffle should be placed above the bottom line of the anodes, the centre-line of the holes being 2 in. above this line and spaced at 8 in. centres. The baffle may be recessed to allow the flow of solution over the top, or a further row of holes, of the same diameter and spacing as mentioned

Fig. 3.—Coil in blister tank.

BAFFLE SEALED AT BOTH ENDS



above, can be cut just below solution level (see Fig. 1). Care must be taken to ensure that the heating coil does not pass directly behind any of these holes, and it will be seen that if for any particular case an arrangement as shown in Fig. 4 is laid out, this particular problem is easily solved. First draw the cross-section of the vat and then the heating coil, and the baffle can then be drawn in with the holes placed accordingly.

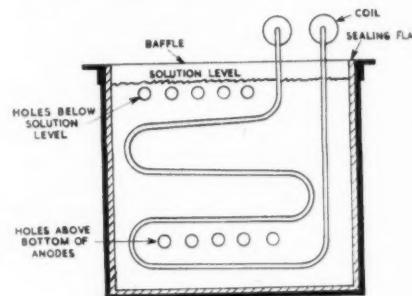


Fig. 4.—Coil and baffle in tank.

It may be found that the above steps eliminate bi-polarity and this can be comparatively quickly checked by the following method. Some strips of mild steel, approximately 6 in. long by 1 in. wide, should be nickel plated to a normal thickness; several such pieces are lowered into the vat so that they rest against different parts of the heating coil and are then left for 24 hours under normal working conditions. When removed for examination it can be easily determined whether they have plated-up, or whether the deposit has plated-off. It is logical to assume that the coil has similar reactions to the pieces of plated steel, and thus if some pieces show plating-up and some plating-off, the coil will be relatively cathodic and anodic at these respective points. If this is the case, the coil can be made effectively uni-polar by connecting it to the cathode via a series resistor. It must be stressed that such action should not be resorted to until the first mentioned steps have been put into practice.

The series resistor performs two functions, first, it controls the cathodic potential of the heating coil and second, it limits the amount of current flowing between the cathode and the coil. It is necessary to connect the coil to the cathode to prevent deterioration, but by so doing the tendency is for the coil to plate-up; it is this secondary effect that is limited by the resistor. The amount of plating-up or the rate of deposition of nickel onto the heating coil will depend upon the applied current density, if this current density is reduced to its lowest possible value the amount of build-up will also be very small.

(continued in page 298)


 The logo features the word "FINISHING" in a large, bold, italicized serif font. The letter "F" is partially obscured by a circular graphic element. To the right of "FINISHING", the word "POST" is written in a smaller, bold, sans-serif font. The entire logo is set against a dark background with a horizontal line underneath.

A SELECTION OF
READERS' VIEWS COM-
MENTS AND QUERIES
ON METAL FINISHING
SUBJECTS

Advice on all aspects of metal finishing practice is offered on these pages, and while every care is taken to ensure the accuracy of information supplied no responsibility can be accepted for any loss which may arise in respect of any errors or omissions.

Tungsten Electrodes in pH Measurement

Dear Sir,

I wish to correct the impression given by R. S. Evans, M.A., in his article "The Development of Modern pH Instrumentation and its Application in Metal Finishing", (METAL FINISHING JOURNAL, Vol. 2, No. 15-16, p. 86), in respect of tungsten electrodes.

Tungsten electrodes maintain steady but somewhat arbitrary potentials under constant conditions of pH which are unaffected by changes in redox potentials. The construction of tungsten electrodes is more rigid than that of other reference electrodes, e.g., calomel, and hence a suitable cell may be obtained from a system such as tungsten and bright platinum where it is required to measure changes rather than absolute values of redox potential. The cell mentioned, calomel *versus* tungsten, would not be expected to indicate redox changes under conditions of controlled pH.

Yours faithfully,

V. E. GRIPP, Ph.D.

Stoke Poges,
Bucks.

Dr. Gripp's comments were submitted to Mr. Evans, who has replied as follows:

The main point regarding oxidation-reduction potential measurement is that the metal electrodes concerned respond both to changes in the oxidation-reduction balance of the solution and to changes in pH. The obvious instance of this is the platinum electrode, which when immersed in a solution to which quinhydrone has been added (thus holding the E_h value constant) acts as a pH indicator.

In fact a tungsten/calomel electrode system is a satisfactory indicator in, for instance, the titration of chloride with silver nitrate, and has the added advantage of providing a great overall change of potential during the course of the titration. If a platinum-tungsten system is used (as Dr. Gripp suggests) the overall change is small making the end point more difficult to detect and showing that the two electrodes follow one another very closely throughout the reaction.

Anodized Aluminium Car Trim

Dear Sir,

In the report of the Conference of the Institute of Metal Finishing published in your issue of May,

1956, the summary of certain of my own statements made at the Conference does not make my meaning entirely clear, and I would be glad of the opportunity to clarify this.

When I referred to anodizing to a "very thin film", I was speaking of film thicknesses of the order 0.0002-0.0003 in. thick. (Not microscopic films of 2-4 microns.) Such a film, although it impairs the reflectivity of electropolished commercial-purity aluminium on a flat surface, tends to cause little apparent loss on a curved surface. I continued my comments by referring to enhancing the protective value of such an anodic film by sealing in such materials as lanoline, waxes, silicones, or even motor oils.

The use of commercial-purity materials in motor car trim must further be considered for coloured applications. After all, the cars of the past looked very attractive in their polished brass—why not brass coloured aluminium—there are two durable methods of colouring available—either a natural anodizing finish in oxalic acid, or a yellow-orange iron oxide colour produced by ammonium ferri-oxalate dip. Our direct competitors in the United States, whom we seem often so keen on following like lambs after sheep, have been producing coloured trim on motor cars for some time—must we always lag behind?

Colour is the vogue of design in these times and commercial-purity aluminium could have an outlet vast in many fields if only we could dislodge ourselves from our trim chromium-plated pedestal.

Yours faithfully,

J. M. KAPE.

Gerrards Cross,
Bucks.

Chromium-Plated Brass Strip

1282.—We are anxious to obtain a quantity of chromium-plated brass strip but have so far been unable to locate a source of supply. We would be grateful for any help you can give us by putting us in touch with a manufacturer of this material.

None of the four manufacturers of electro-coated sheet and strip in this country is at present undertaking the production of nickel- or chromium-plated brass. A demand undoubtedly exists for this type of material and it is to be hoped that supplies of all metals in a range of finishes will be made available before too long.

Stoving by Convection

(Continued from page 294)

minutes at a temperature of approx. 350° F. Fig. 10B shows another Griffith conveyor oven installation of the camel-back type. It is a direct gas-fired type, used for the stoving of a protective black coat of a bitumen-type paint. The stoving time achieved is here 15 minutes at 400° F. Fig. 10C illustrates a very large direct gas-fired Griffith conveyor oven used for stoving of motorcycle components. Either synthetic or oil-based paint is used for coating according to component and requirements. Stoving is performed in this installation for 30 minutes at temperatures which vary between 260 and 450° F, according to need. As can be seen an efficient conveyor system is applied. Fig. 10D shows a Griffiths conveyor oven incorporating a Monorail conveyor system with fixed carriages. This plant deals with small metal components carried through the stove on trays. The products vary widely and so do their finishes and stoving times. The paints used are generally of special formulation requiring stoving from 20 minutes up to 60 minutes at temperatures between 250 and 600° F.

Some oven types of smaller size have been designed for automatic dipping, but for larger conveyor stoves the hand-dipping station is built in together with the enclosed draining section, thus excluding dirt and dust from settling on articles.

In conclusion, the fact should be emphasized that a drying and/or baking oven is usually only one of the units of plant equipment used in series or mass production. If the stove is an efficient element in a plant the flow of goods will proceed as required. On the other hand if the drying or baking operation produces a bottleneck in the flow of articles during production, two ways are open for improvements. Where stoving equipment is not too old, some re-designing and reconstruction might easily help, and with co-operation between plant management and oven designer, a low-cost solution can be usually found for improvements. In instances, however, where stoving equipment is really outdated, a complete replacement of an old oven will be the cure for otherwise endless troubles. Modern stoving equipment and methods can pay for themselves out of increased production, giving a more uniform and better finish, savings in material, labour and fuel; in addition, visible and invisible savings are derived from avoiding rejects.

(To be concluded)

Bibliography

Carne, J. B. "The Role of Convection in Medium Temperature Processing", *Fuel in Science and Practice*, 26, (4).
 Sharples, J. T. "Heating by Electrical Elements", *Journal of Inst. Fuel*, 1951, March.
 Clegg, R. R. "Drying Technique". Paper presented at a Symposium "A Study in Drying" to the Institute of Fuel, January 30, 1951.
 Sprague, J. M. "Metal Finishing as applied to Industrial Heating and Ventilating Equipment", *The Heating Engineer*, 1952.

Bi-Polarity of Nickel Heating Coils

(continued from page 296)

It has been discovered both experimentally and empirically, that with the following results plating-up is kept to a minimum:-

Anode to coil voltage: 0.5 to 0.7 volts.

Current flowing through resistor: 0.5 to 1.0 amp.

The resistor should therefore be adjusted to give readings within this range by the following procedure. The coil should be connected to the cathode through a variable resistor and an ammeter, a voltmeter should also be connected between the anode and the coil (see Fig. 5). The resistor should be adjusted, while readings of the ammeter and voltmeter are taken, until the required readings are obtained. The voltmeter should then be connected across the resistor, and the reading will give the required wattage rating of the permanent fixed resistor by the application of Ohm's Law.

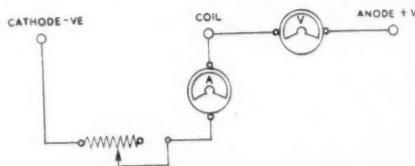


Fig. 5.—Circuit diagram.

As stated, the above notes refer only to a plain coil of pure nickel, but if the second mentioned method of heating is used, i.e., a coil of pure nickel covered with an insulating material, then bi-polarity is not experienced as long as the covering remains intact. Should the covering be damaged for any reason and the nickel be exposed to the solution, the danger from bi-polarity is present, and, due to the small surface area exposed, the current densities will be greater than for a plain coil. In such cases the affected coil should be treated exactly as laid down for a plain coil.

Experience with the third method of heating, i.e., an external heat exchanger, has so far shown it to be free from dangers of bi-polarity. While the heat exchanger has this advantage, on some small vats it is more expensive to install than a heating coil. This is due to the fact that some such vats are not fitted with a continuous filtration system; and therefore to use a heat exchanger, a separate pump and pipe lines must be installed, increasing the initial expenditure. On large vats the difference in capital outlay is negligible because the heat exchanger can be fitted into such a continuous filtration system with which these vats are generally fitted.

Acknowledgement is due to the Electro-Chemical Engineering Co. Ltd., for permission to publish this article.



Sir ERNEST CANNING

*Personality Spot***Sir ERNEST CANNING**

SIR ERNEST ROBERT CANNING, who earlier this month celebrated his 80th Birthday, came to Birmingham from Binton, Warwickshire, at the age of 10 and was educated at King Edward's Grammar School at Aston. On leaving school at the age of 16 he started work with the company of T. L. Hemming, makers of Hemming's patent dynamo as an apprentice, later becoming a partner in the parent company of W. Canning and Co. which had developed considerably in the manufacture of plant and materials for the electroplating and metal finishing industries.

In 1920 when the company was incorporated he became chairman and managing director. Upon relinquishing the position of managing director in 1953 he paid tribute to the work of his late brother who had laid the early foundations of the business. Sir Ernest still retains the position of chairman of the company.

Keenly interested in political, church and social activities, Sir Ernest has been president of West Birmingham Unionist Association, chairman of the Birmingham Unionist Association, a City Magistrate, and a Life Governor of Birmingham University. He entered the City Council in 1930, becoming Lord Mayor in 1937-38, and was elected Alderman in 1939.

Sir Ernest received his Knighthood in 1939 and was High Sheriff of Warwickshire in 1946-47.

His social interests include the British Legion, the Boy Scouts, and the National Playing Fields Association, and in such time as is left to him for recreation he enjoys shooting and playing golf.

FINISHING

NEWS REVIEW

Corrosion Meeting

BY arrangement with the British Iron and Steel Research Association, the Iron and Steel Institute is organizing a Corrosion Meeting to be held at its offices, 4 Grosvenor Gardens, London, S.W.1, on Friday, October 12, 1956, commencing at 10 a.m. and continuing all day. The Chair will be taken by Dr. H. H. Burton, C.B.E., President of the Institute, supported by Dr. J. Pearson, Assistant Director of the Association.

PROGRAMME

10-11 a.m.—"The Corrosion Resistance of Low-Alloy Steels". By J. C. HUDSON and J. F. STANNERS.

11 a.m.-12 noon.—"The Corrosion Resistance of Wrought Iron". By J. P. CHILTON and U. R. EVANS.

12 noon-12.15 p.m.—Interval.

12.15-1.15 p.m.—"Corrosion Resistance of Some Austenitic Cr-Ni Steels of 18/8/Ti Composition. The Effect of Variation in Chemical Composition and Thermal Treatments". By E. J. HEELEY and A. T. LITTLE.

1.15-2.30 p.m.—Buffet Lunch in the Library.

2.30-3.30 p.m.—"Effects of Sulphate-

Chloride Mixtures in Fuel-Ash Corrosion of Steels and High-Nickel Alloys". By H. T. SHIRLEY.

3.30-4.45 p.m.—"The Stress-Corrosion Cracking of Austenitic Stainless Steels". Part I. "Mechanism of the Process in Hot Magnesium-Chloride Solutions". By T. P. HOAR and J. G. HINES. Part II. "Fully Softened, Strain-Hardened, and Refrigerated Material". By J. G. HINES and T. P. HOAR.

This is an open meeting. Anyone interested in the subjects for discussion is welcome to attend and join in the proceedings, even though not a Member of The Iron and Steel Institute. Non-members should write to the Secretary of The Iron and Steel Institute (4 Grosvenor Gardens, London, S.W.1), intimating their wish to be present; a detailed programme and a reply form enabling them to apply for reprints of the papers and for buffet lunch tickets will then be sent to them. Early application for the programme and reply form is desirable.

Essays on Corrosion

Results of S.C.I. Corrosion Group Competition

LAST October the Corrosion Group of the Society of Chemical Industry announced an essay competition designed to encourage young technicians to take an interest in corrosion science. A prize of 25 guineas was offered for an essay or paper on any aspect of corrosion of metals and its prevention.

Following the judging of the entries the judges have reported that they have found the task of selecting the winning entry from the total of fifteen received one of great difficulty. They are, however, pleased to report that the sources of their difficulty, namely the wide choice of subjects chosen by entrants and the generally good standard of the entries, were very welcome indications of the usefulness of the competition.

The judges consider that the closeness between the merits of several of the entries should be recognised by an increase in the total prize money and by the award of one prize of 20 guineas and two of 7 guineas each instead of one prize of 25 guineas. They have

accordingly awarded a prize of 20 guineas to J. F. Light (Bexleyheath, Kent) for his entry "The Problems of Corrosion Interference Associated with the Application of Cathodic Protection to Buried Structures" and prizes of 7 guineas each to R. Tate (Montreal, Canada) for his entry "Corrosion: its Implications to Aircraft" and to M. A. Pearson (Birmingham) for his entry "Hydrazine as a Corrosion Inhibitor". They also wish to express their commendation of the entry of G. M. W. Mann (London) "The Use of Statistics in Corrosion Research".

In assessing the entries, the judges have considered literary style, originality of thought, arrangement and development of argument. They have been impressed by the generally good level of literary quality and have found the most common weaknesses to be the omission of or inadequate attention to objections that might be raised to the views advanced and in the presentation of the conclusions.

FINISHING COURSE AT BURNLEY

FOLLOWING the completion of a two-year course for the City and Guilds Course 17A Operatives Course in Metal Finishing at Burnley Municipal College (as a result of which six out of eight candidates were successful) it has been announced by the College authorities that if sufficient students are forthcoming a similar course will be started in September this year to run for two years on Monday and Friday evenings from 7 to 9.30 p.m.

Anyone interested in participating in this course should communicate with the Head of the Science Department, Burnley Municipal College, Ormerod Road, Burnley, Lancs.

ION-EXCHANGE AND ITS APPLICATION

A COURSE of lectures on "Ion-Exchange and its Applications" will be given at Battersea Polytechnic on Thursday evenings, commencing on October 4 with an introductory lecture by D. K. Hale, M.A. On October 11 D. Reichenberg, M.Sc., will speak on "Principles of Application" and on October 18 Dr. T. V. Arden, F.R.I.C., will deliver a lecture on "Industrial Developments". Dr. J. E. Salmon, F.R.I.C., will deal with "Developments in Inorganic and Analytical Applications" on October 25, and on November 1 a lecture entitled "Developments in Organic and Biochemical Applications" will be given by Dr. R. E. Kressman, D.I.C., F.R.I.C. The fee for the course will be 10s. and application forms should be obtained from the Secretary (Ion-Exchange Course), Battersea Polytechnic, Battersea Park Road, London, S.W.11.

A. E. GRIFFITHS (Smethwick) LTD.

We regret that owing to a printer's error in the advertisement of A. E. Griffiths (Smethwick) Ltd., on page 3 of our June, 1956, issue, the captions to the two lower illustrations were transposed.

Several entries, however, merit publication (with some amendment) and the judges feel that the competition has been of some service in providing an incentive to the production of ideas in writing. They recommend strongly that the competition be repeated.



TECHNICAL AND INDUSTRIAL APPOINTMENTS

It has been announced by **Byron Botterill and Son Ltd.**, 278 Rockingham Street, Sheffield, manufacturers of grinding and polishing materials that Mr. K. M. Price has joined the company as director and general manager and that Mr. Albert Doyle has been appointed director and secretary.

Mr. A. W. Morrison, B.Sc., D.R.T.C., A.I.I.A., has joined **Expandite Ltd.**, Chase Road, London, N.W.10, as technical manager responsible for production and development. He was at one time secretary of the Cremer Committee on Chemical Engineering Research in Great Britain.

Mr. J. Dunning, B.Sc., A.I.M., A.M.C.T., at present senior lecturer in metallurgy at Wolverhampton and Staffordshire Technical College, has been appointed Principal of a new and as yet unstaffed technical college at Redcar, near Middlesbrough, Yorks. He is likely to take up his new appointment at the beginning of 1957 so that preparations can be made for an opening session in September of that year.

At the Annual General Meeting of **Norton Grinding Wheel Co. Ltd.**, held recently, Mr. Alfred E. West and Mr. John B. Morrison were appointed directors of the company. Mr. West is the firm's chief accountant and Mr. Morrison general works manager.

At a recent meeting of the board of directors of **Keith Blackman Ltd.** the following executives were appointed to serve as directors: Mr. C. J. Atkins, sales director; Mr. F. W. Goodge, contracts director; Mr. S. Hudson, director and London works manager. At the same time, Mr. A. H. Woodley was appointed sales manager.

At the Annual General Meeting of the **Scientific Instrument Manufacturers' Association**, Mr. G. A. Whipple, chairman and managing director of Hilger and Watts Ltd., was installed as president for the coming year. Mr. P. Goudime, Electronic Instruments Ltd., was elected vice-president.

TRADE and TECHNICAL PUBLICATIONS

Automatic Plating Plant: A emulsion concentrate; Proferoscal de-oxidant two-page leaflet produced by the rustet and descaler; Chalco deoxidising Division of Silvercrown ing powder; barrel finishing com- Ltd., 178-180 Goswell Road, London, pounds; and a dewatering fluid. E.C.1, illustrates and describes the advantages of automatic plating plant.

It states that automatic plating plant has transformed plating from an untidy and tiresome manual process to a clean and precision engineering operation and that it is suitable for electroplating, phosphating and other metal finishing processes. It claims that automatic plants pay with even medium outputs. Other advantages claimed are that a saving in man hours; the use of unskilled labour; reduction in production costs; ease of operation; fixed processing times; flexible but pre-selectable output; and consistent quality of finish.

Chemical Oxidation Process for Aluminium: This pamphlet produced by the Walterisation Co. Ltd., Purley Way, Croydon, deals with the application of the Walterisation L. process to aid the adherence of paint, lacquer or enamel coatings to aluminium or aluminium alloy surfaces.

It states that an effective cleaning of all metal surfaces should be a rigid practice in all metal finishing treatments. Since the Walterisation L. solution is alkaline, it is not necessary to degrease as thoroughly as before most other finishing treatments.

The correct operating temperature of the bath is given, and it is pointed out that the highest operating temperature that does not cause a powdery deposit to be formed, should always be used. The method of treatment is explained, and also the treatment to be given after processing as well as the plant required for the degreasing, processing, rinsing, drying and finishing operations.

Cleaning Problems: A new booklet published by the Despo Manufacturing Co. Ltd., 30 Pancras Road, London, N.W.1, deals with the company's products that are available for degreasing, descaling and metal finishing.

The booklet states that the company offers a complete service in the treatment of metal surfaces and advice on the most suitable treatment of products. Before any treatment such as plating, galvanizing, enamelling, painting or lacquering, it is essential that the surfaces are clean. The booklet lists the company's products for achieving this and describes the constituents and the method of application. The products discussed include D.P. cleaner and degreaser;

Centrifugal Fans: A brochure produced by Keith Blackman Ltd., Mill Mead Road, Tottenham, London, N.17, describes two of the company's new types of Tornado centrifugal fans designed in p.v.c. specifically for fume removal.

Series 1 fans which will be in production in the near future will cover duties of 50 to 2,500 cu. ft. per min. up to 4-in. w.g. pressure.

Series 2 are now available for handling from 2,000 to 40,000 cu. ft. per min. and also for pressures up to 4-in. w.g.

The brochure states that the p.v.c. material used for these fans is resistant to chemical attack, dimensionally stable, non-inflammable, and has a relatively high impact strength.

Series 1 fans are of the direct motor-driven type while those in Series 2 are of the indirect pulley-driven type.

"Canning Quarterly News": The August issue of this journal published by W. Canning and Co. Ltd., Birmingham, contains news and reports of the company's activities over the past three months.

The Annual General Meeting is dealt with and it states that the last year was a record one for the company even though there is the problem of the "Credit Squeeze", the nickel supply position, and competition from foreign interests.

Two full pages are devoted to an abbreviated reprint of an article which appeared in this Journal dealing with the automatic copper-nickel-chrome plating plant which the company installed at the Luton Works of Vauxhall Motors Ltd.

Other articles deal with a "Plating Shop On Wheels", which describes how one of the company's products was used in Egypt during the war, and the question of automation in the metal-finishing industry.

The Nickel Bulletin.—The increasingly close inter-relation of metallurgy and the development of atomic energy is demonstrated by the literature abstracted in The Nickel Bulletin for July, issued by The Mond Nickel Co. Ltd., Thames House, London, S.W.1.

Attention is also directed to two comprehensive summaries of information on corrosion problems arising in the petroleum industry, and to papers concerned with the welding of heat- and corrosion-resisting materials, including clad steels.

Latest Developments

in

PLANT, PROCESSES AND EQUIPMENT

Shot-Blasting Gun

A NEW form of shot-blasting gun is announced by Vacu-Blast Ltd., 291 Aberdeen Avenue, Slough, Bucks. This equipment—the "High Production Gun" is used with the Vacu-Blast "Senior" machine and has been designed to obtain a high rate of millscale removal from flat plate prior to fabrication. It requires one operator only, and can be operated manually or be self-propelled by means of a variable-speed gun carriage. An 8-in. wide blast-cleaned track is obtained with each pass of the gun and millscale can be removed at an average rate of between 300 and 600 sq. ft. depending upon the condition of the surface to be blasted.

The gun is, in effect, a small blast cabinet (Fig. 1) in which is fitted a rotating-nozzle assembly consisting of three $\frac{1}{2}$ -in. blast nozzles. Abrasive is directed through the blast nozzles on to the work surface and vacuum pick-up returns it, together with the removed surface deposits, to the Vacu Blast "Senior" machine where the abrasive is separated from the debris and then returned automatically and continuously to the gun. A variety of abrasive sizes can be used.

The Vacu-Blast "Senior" Model 260L CC is a continuously cycling, mobile shot-blast machine designed for use with chilled cast-iron abrasive. It consists of a generator-reclaimer unit and a dust collector fitted with a 25-h.p. electric motor and star-delta starter. The machine requires 260 c.f.m.

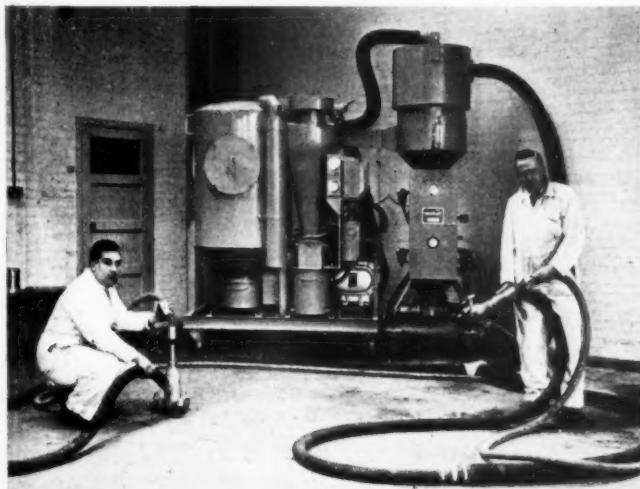


Fig. 1.—Shot-blasting Gun.

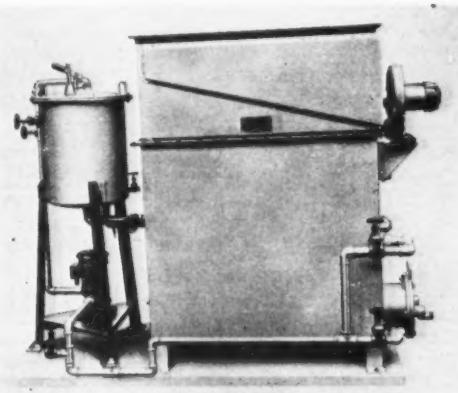


Fig. 2.—Metal Drying Plant.

of clean, dry air compressed to 100 lb. per sq. in. A variety of smaller gun heads can be attached to this machine for plate-edge cleaning, weld slag and scale removal, tube cleaning, and blast cleaning of metal structures after fabrication.

Metal Dryer

A NEW method for drying metal parts rapidly and without trace of water staining has been developed by the German company Wacker-Chemie.

The new method, known as "ASL", consists of immersing the parts to be dried in boiling perchlorethylene to which has been added a special agent. This agent has the property of reducing the adherence of water to the surface of metal and of promoting the transference of heat from perchlorethylene to water. The result is that the water evaporates much more rapidly than in pure perchlorethylene and does not tend to form an emulsion. Due to the speed of evaporation all the impurities in the water are removed simultaneously.

from the surfaces of the metal parts leaving them stain free. Only minute quantities of the additive "ASL" are required, a ratio of 0.1 per cent. by weight of "ASL" to perchlorethylene being satisfactory.

In addition to the "ASL" agent, "ASL" metal drying plant (Fig. 2) is being marketed. This plant incorporates a water separator which ensures that the drying process is maintained without risk of deterioration due to water contamination of the bath.

Roto-Finish Limited, Mark Road, Hemel Hempstead, Hertfordshire, are the sole United Kingdom suppliers of "ASL" metal drying plant and "ASL" additive.

Spray Booth Maintenance

AN improved material, developed to reduce pre-mixing operations and to work at lower concentrations than the older but similar material Detac No. 1 is the new Detac No. 3 water-conditioning agent, a readily soluble mixture for the treatment of recirculating water in water-conditioned paint spray booths. It is produced by The Pyrene Co. Ltd., Metal Finishing Division, Great West Road, Brentford, Middlesex.

Its function is to reduce the labour required to maintain paint spray booths in a clean and efficient condition. It achieves this by denaturing the overspray, and, by removing all stickiness, preventing its adhesion to reservoir walls, eliminator plates, filter screens and pumps. Also, the denatured paint tends to float on the surface of the water in the reservoir from which it can be skimmed by appropriate means as required. In the case of water treated with Detac No. 3, the period of flotation is a maximum.

It is also perfumed to combat the smell of drowned paint and maintains freshness and can be used in all types of paint spray booths where the water system is of a re-circulating type.

Before use in a paint spray booth, the complete equipment should be thoroughly cleaned. When the reservoir has been re-filled, Detac No. 3 powder should be added at the rate of 5 lb. for every hundred gallons of water. The powder is readily soluble, but where very rapid dissolution is required this can be facilitated by dissolving the required quantity of powder in a separate vessel ahead of time, and then adding this concentrated solution to the booth reservoir.

All that is then required for maximum booth efficiency is to maintain the solution at the correct strength by periodical small additions of the powder.

In all circumstances the regular removal of denatured paint by skimming the surface of the water in the reservoir is recommended as standard practice.

The powder is packed in 56 lb. and 1 cwt. sized steel drums.

Classified Advertisements

Prepaid rates: FIFTEEN WORDS for 7s. 6d. (minimum charge) and 4d. per word thereafter, or 24s. per inch. Box number 2s. 6d., including postage of replies.

NORTH STAFFORDSHIRE TECHNICAL COLLEGE, STOKE-ON-TRENT. COLLEGE OF CERAMICS

*Principal:
H. W. WEBB, O.B.E., D.Sc., F.R.I.C., M.I.Chem.E., F.I.Ceram.
Head of Department:
W. L. GERMAN, M.Sc., Ph.D., F.R.I.C., F.I.Ceram.*

Courses in Vitreous Enamelling

SESSION 1956-57

Classes begin Monday, September 17, 1956.
Interviewing Week: September 10 to 14 inclusive.

Full-time Course in Vitreous Enamelling leading to the Manager's Diploma

This is a full-time course of three years' duration on the Sandwich scheme, involving six months full-time study at the College and six months on a works in each year. The course includes VITREOUS ENAMELLING, METALLURGY, ENGINEERING, CHEMISTRY and MANAGEMENT SUBJECTS.

Part-time Course in Vitreous Enamelling

This is a less comprehensive course of three years' duration in VITREOUS ENAMELLING and METALLURGY, intended for those who can only be released from work on two half-days each week.

Full-time Course for Diploma in Ceramics

This is a three year full-time course intended for SCIENTIFIC PERSONNEL. The subjects are CHEMISTRY, PHYSICS and CERAMICS (including VITREOUS ENAMELLING).

Specialist Lectures on the Production of Vitreous Enamelled Ware

A series of twelve weekly lectures on the production aspects of vitreous enamelling of sheet steel and castings will be given on Tuesday evenings from 5.15 to 6.30 p.m. commencing on September 25, 1956. These will be given by well known technologists from the industry.

Further details of the courses can be obtained from the Principal.

SITUATIONS VACANT

VITREOUS ENAMELLING

A YOUNG ENGINEER to exercise laboratory control over the materials and processes used in a modern continuous vitreous enamelling plant installed at the Works of a leading manufacturer of Domestic Appliances.

Applicants should have some practical experience in the operation of a modern vitreous enamelling plant and preferably an H.N.C. in Chemistry.

Housing assistance can be offered to suitable applicants.

Reply in confidence to Box MF 877, L.P.E., 55 St. Martin's Lane, London, W.C.2.

BARREL POLISHING

by Polymotion Machinery for the trade on contract basis
FOX CHEMICAL ENGINEERING WORKS LTD.,
MAYBURY GARDENS, WILLESDEN HIGH ROAD,
LONDON, N.W. 10 Tel.: WILlesden 6201

